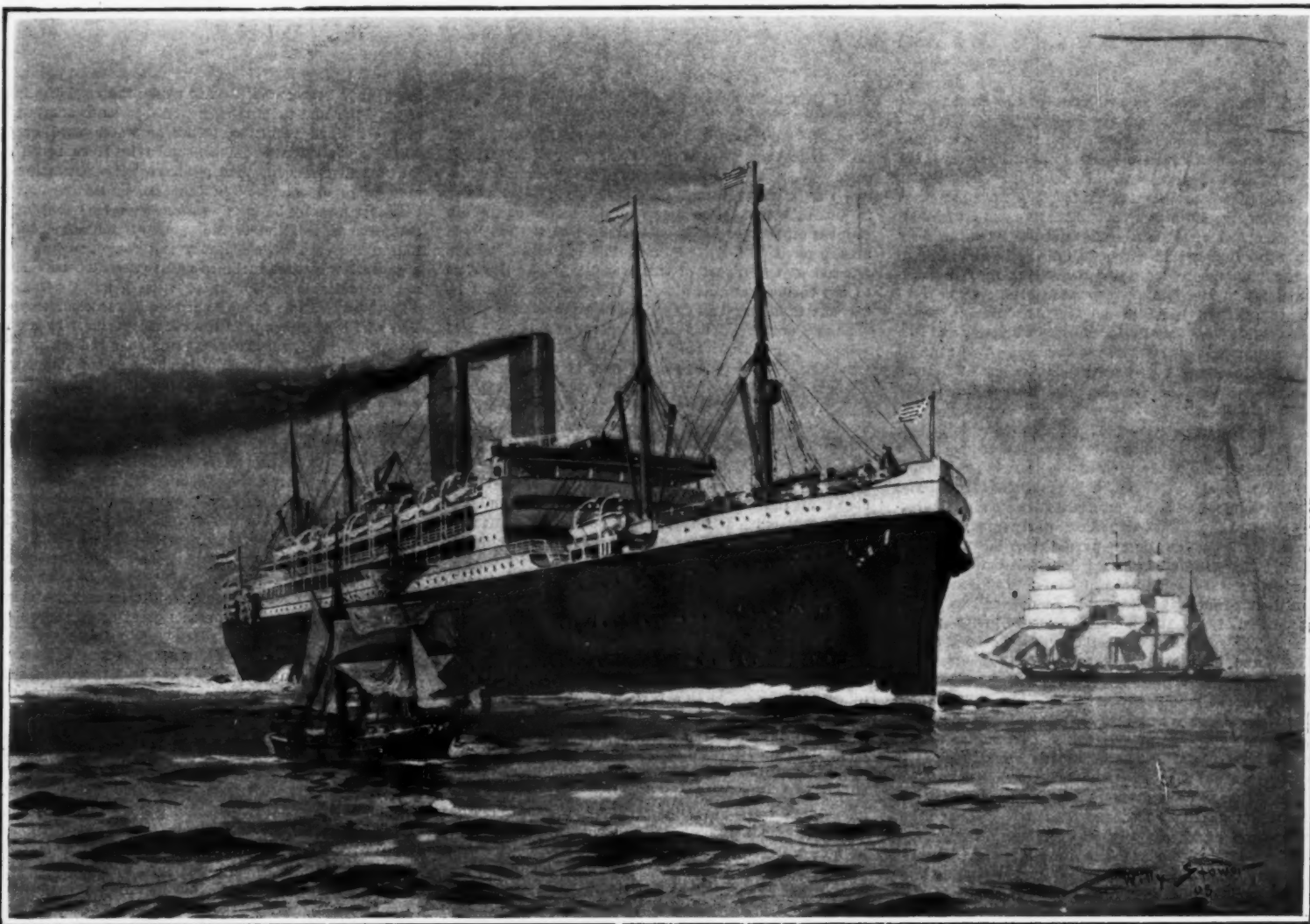## THE STEAMSHIP "GEORGE WASHINGTON."

THE "George Washington" is the very latest type of passenger and freight-carrying steamship. Every innovation, improvement, and achievement known to the shipbuilding industry is typified in the "George Washington." She is the only steamship of the North German Lloyd to exceed 20,000 tons gross register, and is the largest German-built and owned steamer in the world. The vessel is about one-fourth again as large as the fast express steamships "Kronprinzessin Cecilie" and "Kaiser Wilhelm II." of the same line.

The American Ambassador to Germany, Dr. David Jayne Hill, christened the steamship.

In roominess this new giant of the ocean is unsurpassed; and while comfort and safety were given precedence over all other considerations, the "George Washington" will have a speed of not less than 18.5 knots per hour, which is sufficient to make the crossing in less than seven days.

Some idea of the colossal proportions of the "George Washington" may be had from the following dimensions of the vessel:

Length, 722 feet 5 inches; beam, 78 feet; depth from upper saloon deck, 54 feet; depth from awning deck, 80 feet; displacement at draft of 33 feet, 36,000 tons; number of passengers, 2,941; crew, 525; cargo capacity, 13,000 tons; gross registered tons, 27,000; and two four-cylinder quadruple expansion engines of 20,000 indicated horse-power.

The "George Washington" is more than one-seventh of a mile in length, and if stood on end would tower 167 feet above the gigantic monument erected in Washington, D. C., to the memory of the man for whom the vessel is named. From the keel to the point of the highest mast is as great a distance as is occupied by the sixteen stories of the Waldorf-Astoria, and is two-thirds of the height of the Flatiron building.

The ship will carry 520 first-cabin passengers; 377 second-cabin; 614 third-cabin, and 1,430 steerage, and in addition a crew of 525, making in all 3,466 persons. This number is greater than the organized militia force of any State in the Union, except New York, Pennsylvania, Ohio, New Jersey, Illinois, and Massachusetts. It is in excess, too, of the number of men engaged in the Seminole war of 1856-58, or the war with Tripoli in 1801-05.

Some of the innovations on the "George Washington" are the elimination in the cabins of the first class of upper berths, great number of rooms with baths, children's playroom; two electrically-worked elevators for passengers; a great solarium or lounge, sumptuously fitted and furnished, and covered by a great vaulted dome of cathedral glass; complete electrical equipment; extraordinarily wide berths; great two-storied smoking-room for passengers of the first class; magnificently equipped gymnasium, electric light baths; hot and cold fresh and salt water at all times, running water in rooms; dark room for the use of amateur photographers; and on the boat deck are twenty specially constructed kennels, in charge of a

competent kennel master, where the pets of passengers may be placed during the trip, and at the same time receive the best of care.

The establishment of a third class on the "George Washington" is a departure. This was done in order to accommodate those persons of moderate means who found the prices charged for second-class passage too high, yet who did not wish to travel in the steerage. The rooms for passengers of the third class are in the after part of the ship, being arranged to accommodate two, four, and six persons.

The main dining room, which is most spacious, is amidships on the saloon deck, covers an area of 5,918 square feet and contains seats for 470 persons.

The "George Washington" is constructed as a first-class twin-screw passenger and freight steamship with keelson and flat keel, vertical stem, elliptical stern and bilge keels. The best German steel was used in the construction of the "George Washington," which is classed as a five-steel-deck ship of the highest type. The vessel is equipped with a water-tight double bottom, extending the entire length, divided into twenty-six compartments. In the various compartments 138,250 cubic feet of fresh, drinking, and water ballast may be carried. Twelve water-tight transverse bulkheads, all reaching to the upper deck, and some even to the upper saloon deck, divide the ship into thirteen watertight compartments, so arranged that even though two adjoining compartments should fill with water, the ship's stability would in no wise be affected. The bulkheads are constructed in accordance with the rules of the Germanic Lloyd and are so strong that

From the Illustrirte Zeitung.

THE RECENTLY LAUNCHED NORTH GERMAN LLOYD STEAMER "GEORGE WASHINGTON."

one-sided water pressure can easily be withstood. The steam pumps on board can dispose of 2,500 tons of water an hour.

Other safeguards for the ship and passengers are a bell system for fire-extinguishing purposes with 14 alarm bells leading to the main quarters of the crew; a complete alarm-bell system with 30 bell stations for the ship and engine-room system; a fire-reporting system, with 18 fire-alarm stations scattered over the vessel.

A submarine bell signaling apparatus permits the ship's officers to know of the proximity of another vessel or coast when from seven to twelve miles distant. This system is of benefit in enabling the ship's officers to keep to their course when approaching or leaving port in foggy weather.

On the "George Washington" there is suspended at the stern a life buoy, which can be dropped overboard by the turning of a switch on the bridge. It is expected that this device will prove of use in the event of passengers falling or jumping overboard, as the buoy can be released and dropped astern before the person in the water is passed.

Among the other safety devices on board are the wireless telegraph station, enabling passengers to keep in communication with the land at all times; a complete system of telemotors, engine telegraphs, rudder telegraphs, etc.

Steam is furnished by eight double and four single-cylinder boilers, requiring sixty fires having a grate surface of 1,227 square feet. The two funnels are 113 feet above the keel.

The 520 first-cabin passengers are quartered in 263 rooms; the 377 second-cabin passengers in 137 rooms; the 614 third-class passengers in 160 rooms, and the 1,430 steerage in eight compartments. The working force of 525 men, constituting the crew, consists of 22 officers, doctors, pursers, and postal clerks; 35 engineers and machinists, electricians, boilermakers, and oilers; 129 head firemen, firemen, and coal passers; 196 stewards, stewardesses, and steerage waiters; 40 scullery and pantry men; 37 cooks, bakers, butchers, and confectioners; 10 barbers, hairdressers; booksellers, printers, baggagemasters, and wireless telegraph operators, and 56 mates, boatsmen, carpenters, sailmakers, and sailors.

The "George Washington" was built in the yards of the Stettiner Vulcan at Bredow, and will enter the New York-London-Paris-Bremen service of the North German Lloyd in May or June next.

More than 14,500 tons of the best steel was used in the construction of this new colossus. To transport this mass would require 483 freight car each with a carrying capacity of 60,000 pounds. This would make 16 trains of 30 cars each, or a continuous line of freight cars reaching from the Battery to Union Square. No less than twenty-eight carloads of bolts, nuts, and screws were used in the construction of the new steamship.

The rudder and spindle weigh 45½ tons. Other material used were 460 tons of wrought and cast iron; 35,000 cubic feet of teakwood; 74,000 cubic feet of Oregon pine, and 42,000 cubic feet of pitch pine.

MARINE ENGINEERING, PAST, PRESENT, FUTURE.

FROM RECIPROCATING ENGINE TO TURBINE.

Mr. James Denny, as president of the Institute of Marine Engineers, London, in his address took for his subject some recollections and lessons and their application, drawn from an experience of fully forty-three years of marine engineering. He said, the changes that have occurred during this period, the advances that have been made in marine engineering, will undoubtedly compare with the changes and advances made by any other industry in the country. Perhaps the progress during the period being dealt with may be illustrated if we take two vessels, both for the same owners, the British India Steam Navigation Co.; one of these, the "India," built in the early sixties, and the other, the "Rewa," built two years ago. The "India" was 230 feet long by 30 feet beam, about 1,000 tons, and the "Rewa" 455 feet long by 56 feet beam, and about 7,000 tons. The "India" was fitted with one simple two-cylinder engine, 46-inch cylinders by 3-foot stroke, horse-power about 800; the water consumed per I. H. P. must have been approximately 30 pounds, but no accurate observations were then taken. The "Rewa" is fitted with three turbines with a shaft horse-power of about 10,000, and the water per shaft horse-power is 15 pounds for all purposes at the maximum speed. The "India" had two flat-sided boilers for 25 pounds pressure, with natural draft; the "Rewa" had two double-ended and four single-ended boilers of the cylindrical type, 155 pounds pressure, with forced draft. The speed of the "India" on trial was about 10 knots, and of the "Rewa" touching 19 knots. The "India" was the typical vessel of her fleet in her day; you will note that since then the tonnage—taking these two vessels as a comparison—has been increased seven-fold, the speed practically two-fold, and the power fully tenfold. These are the broad bare facts and they show a sufficient advance, but in detail the differences are even greater. In the "India" the engine room auxiliaries consisted of one steam donkey pump and one hand pump, while the number of pipes in the machinery space was in all seventy; in the "Rewa" there are thirty-five auxiliary pumps and engines of various kinds, and 960 lengths of piping. The "Rewa" was fitted with hydraulic gear, electric light, refrigerating machinery, all of which were unknown forty years ago.

In the period under consideration, we have come then from the simple engine with jet condenser and 25 pounds pressure to the same engine with the surface condenser, then to compound engines with 60 pounds pressure, then to triple expansion engines with 160 pounds pressure, then to quadruple expansion engines, with from 200 to 220 pounds pressure, and now to turbines, with a possible development of triple or quadruple engines in combination with turbines. The steam turbine, especially for marine purposes, is still in its infancy, although a very sturdy infant it has grown to. Practically all marine turbines, so far, have been of the Parsons' type, but there are others, notably the Curtis, an American invention, for which excellent results are claimed. Mr. Parsons will be entitled to and receive all the honor due to the pioneer who has fought the fight and borne the stress that pioneer work inevitably necessitates. All others must simply be followers in his footsteps and reapers of profit by the good work he has accomplished.

It has frequently been suggested that if some inspired engineer would evolve a system of gearing that would be lasting and reliable, not too noisy, and would not absorb in friction more than say 10 per cent of power, turbine engines would be capable of application to any speed of vessel and to any size of propeller; you could then have a high-speed turbine and a low-speed propeller, which is the ideal condition for marine propulsion. This condition it is considered may be met in another way. The system devised by Mr. Durtnall consists of a fast-running turbine driving a small dynamo, the latter again transmitting its electrical power to and driving a large slow-running motor or motors coupled directly to the propeller shaft or shafts. This arrangement does not eliminate the loss caused by the friction of the thrust of the propeller, as is the case in the turbine, and as also, by the way, would not be the case in any system of gear-driven propellers; otherwise one cannot but fear that the cost of this electrical system of propulsion will tell against it. A concrete case was recently put before a firm of electrical engineers who were strong advocates of such a system, but not Mr. Durtnall's; it was proposed to fit it in a ship, duplicate of one already at work with triple engines; the problem was the worst possible from the point of view of the advocates of the new system, but it was very carefully gone into and finally abandoned on account of the very considerable extra cost, and the doubt that existed if this would be met by the promised saving in coal consumption, even if the latter were attained.

There is still Mr. Parsons's latest system to test in the adaptation, or rather partial adaptation, of turbines to low-speed vessels: he claims that a considerable economy will be effected by using a higher vacuum than in the case of ordinary machinery, and by interposing between the main exhaust of the ordinary engine and the condenser a turbine driving an auxiliary propeller; that thus he will utilize the final expansion of the steam, which is largely lost in the ordinary engine, due to the smallness of the passages between the low-pressure cylinder and the condenser. There may also in this system be some gain due to the consequent less unequal temperature in the low-pressure cylinder, but that need not be gone into here. This system will be practically tried in a short time in a vessel for the New Zealand Shipping Company, and also in one now launched for one of the Atlantic lines; the results will be awaited with much interest by all interested in shipping. It is quite clearly understood that the crux of the problem is the relative efficiency of three propellers as compared with two, and this can only be determined by such practical experiments as are going to be made. Land installations have shown that the turbine, as arranged above, will give the economy claimed. Even if the first of the three propeller arrangements does not give the results expected, a modification of the stern in the vicinity of the propellers, and of the propellers themselves, may finally bring them about. In any case, the experiment will be a most interesting one, and the owners who have sanctioned it are entitled to every credit for their enterprise.

As has already been said, the turbine is still in its infancy, and this question of the propellers for turbine engines is one which perplexes all who have studied the matter. The best practical remedy seems to be to peg away at trials, obtain all possible data, and tabulate and analyze such data carefully for future use; by this means in time there will be obtained the power of arriving at the best possible results under any given conditions with at least some fair degree of accuracy. You all know that as the turbine increases in the revolutions which are practicable in marine work, its efficiency increases; to obtain high revolutions the propeller sizes must be cut down, but this again decreases their efficiency, and the difficulty has always been and still is to strike the crossing lines of propeller and turbine efficiencies, so as to obtain the best combined result in terms of water used or in what is equivalent—coal consumed into the speed of the vessel. Coal consumed per shaft horse-power is not a measure of efficiency in the case of turbine-driven vessels; the only basis is as already stated—coal consumption in relation to the speed of the vessel, as is indeed the case with ordinary engines. You know in a general way that turbines as at present constructed are not suitable for low-speed vessels, but the reason why this should be so may not be quite so clear to you. You will best understand the reason perhaps by an illustration, always bearing in mind that the peripheral clearance of the blades and dummies is the important factor in the economical working of turbines. Take two vessels, one with a speed of 22 knots and the other with a speed of 12 knots, each requiring 10,000 horse-power for this speed. Design the propellers in each case on the usual basis for turbine-driven vessels, and make the turbines to correspond. In the case of the 22-knot vessel you will have propellers about 5 feet diameter running at nearly 700 revolutions, and in the 12-knot vessel the corresponding figures will be 13 feet diameter and 110 revolutions. Turbines corresponding to these revolutions will have such clearances that in the case of the slow-running vessel the clearance will be about five times as great as in the quick-running vessel. This clearance and its consequent leakage is the cause of want of economy in turbines of vessels running at slow speeds. A high blade in proportion to the diameter of the rotor, which is not admissible in such vessels, seems to be essential to economical working of turbines. While dealing with clearances, your attention may be called to an ingenious and simple invention recently brought out by Mr. Parsons, which he calls "tipping the blades." By this system, which will reduce the blades to a minimum section at the very point, it is safe to run turbines with much diminished clearance, and so increase their economy.

The past has seen great changes in marine affairs. What does the future hold for us? Apparently at least there is to be no standing still. The combination engine and the turbine driving propellers by electrical transmission have been already referred to, but there are other systems that have been suggested and advocated with at least some degree of reason; these are internal combustion engines, gas engines using producer gas, and oil engines: the first and last are used successfully in vessels such as racing launches and craft of small size, but matters are hardly ripe for their introduction on a large scale; the gas engine has also been given a trial, but the results seem so far to be inconclusive. The extended use of the water-tube boiler in vessels where weight is a serious consideration is one of the problems that must be solved sooner or later. Small and tentative experiments in this direction are even now being made by two enterprising bodies of shipowners, the South-Eastern and Chatham Railway Company, and the Irrawaddy Flotilla Company; if these experiments are successful, considerable modifications will take place in Channel and light-draft vessel practice.

There has recently been brought to this country an optical mirror for the Mt. Wilson Observatory, said to be the largest and most expensive ever cast. It is valued at $60,000 and weighs 6,600 kilogrammes, or about six and a half tons. It is 100 inches in diameter and concave in form.

AERIAL PROPELLERS.

OLD AND NEW FORMS.

BY SIDNEY H. HOLLANDS.

Now that legitimate practical flight is well to the front and will probably maintain its interest, thanks to recent signal successes demonstrating its practicability beyond all doubt, a dissertation on propellers will be in order.

The most important adjunct now to the aeroplane machine is the aerial propeller—and the most wanting.

Sustentation and power there is now no difficulty about, but even the best propellers now in use leave much to be desired—of which more anon.

That the screw or helical rotating propeller should have been associated with schemes of aerial navigation no less than four centuries ago, and by no less a personage than the great artist-mechanician, Leonardo da Vinci, at the end of the fifteenth century, is a remarkable fact.

That which appears to the present writer equally as remarkable is the fact that, despite almost innumerable applications of the aerial screw propeller since that remote period, so little improvement in it has been effected.

Leonardo da Vinci's propeller was a screw or helix of a single "worm" or thread—being practically all "worm"—and comprising an entire convolution, of which the modern equivalent would be a single-bladed screw, blades being a much later development.

Now, one can quite understand how the original screw propeller came to be of single "worm" type, and one *complete turn* of the "worm" was deemed essential.

These were matters of subsequent development, the departures being indicated by experiment and trial.

It was first discovered by actual comparative trials that half a convolution of the "worm" was fully as efficient as a whole turn, then that a quarter turn was more efficient than half, but with this curtailment of the helix a formidable difficulty arose. It had now developed into a one-bladed screw, was unsymmetrical, and, consequently, unbalanced. Centrifugal force and one-sided thrust now jointly interposed with inimical results.

Some hard thinking had then to be done, and by and by it dawned on the minds of the pioneer experimenters that the expedient to produce a more efficient, symmetrical, and compact screw propeller—while employing only a fraction of a convolution—was to have two or more "worms," now reduced to blades. Thus it gradually came to pass that the modern true screw propeller in its simplest and most efficient type is but a very short length cut off a two-thread screw, in which the thread is relatively very deep, with a pitch equal to about two-thirds of its diameter. A marked later tendency was to err on the side of plurality of blades (this error is still in evidence).

Thus the Ericsson propeller (marine) was formed of a short section of a 12-thread screw of very coarse pitch, and, naturally, proved very inefficient. The aerial fan propeller of Moy (not a screw) had six broad vanes inclosed in a hoop, and was but little better. The same remark applies to the propellers of Henson, Stringfellow, Linfield, Du Temple, and many others. Even the first propeller fans used by Prof. Langley on his earliest aerial model were six-bladed.

In his subsequent and highly successful "aerodrome" the twin propellers were two-bladed true screws, as also were those of the Maxim machine.

It is a significant fact that the conspicuous successes have all been achieved with two-bladed propellers; indeed, it may now be safely stated for the guidance of future experimenters that it is not worth while again trying any form of multi-bladed propeller. All recent systematic and comparative experiment points to the fact that a two-bladed propeller is the most efficient, and, at the same time, fortunately, the simplest and lightest. The results of the writer's experiments fully indorse this.

It cannot, however, be as definitely or as confidently stated that a true screw is the most efficient form for a rotating aerial propeller. The writer's experience (for one) is at variance with such a conclusion. Neither can one safely reason by analogy to marine propellers. That which is best in the water is by no means necessarily best in the air, and *vice versa*. For instance, we may safely predict that an aquatic propeller made with concave blades would be a conspicuous failure, yet in an aerial propeller with blades so formed I registered the highest efficiency on test compared with numerous other types, including true screws.

Some of the best results obtained hitherto, in recent times, of thrust for brake horse-power applied are: Maxim, 9 pounds; Langley, about 7 pounds; Spencer (with a Maxim type propeller), 6 pounds; Farman, and other experimenters in France, 6 pounds (about).

We will now refer to another type of propeller fan, the flexible-bladed fan, which is so constructed as to give a self-feathering action to the blades, i. e., a self-varying pitch, the air resistance to rotation causing the blades to twist, and so to become of less and less pitch with increasing speed.

This type has found some advocates, but is far from efficient. Experiments have indicated great loss of power.

To the writer such a result seems obvious, and needs no trial. An American experimenter, a Mr. Thaddeus Hyatt, of New York, tested such flexible-bladed fans, three-bladed and of 19 inches diameter. At 480 revolutions per minute the thrust was only *three ounces!* The power was not measured, but at a moderate estimate must have amounted to one-fifth of a horse-power, which would give about *one pound* thrust per horse-power. It is thus clearly not worth while experimenting further with flexible-bladed propellers.

A sound rule in aerial propeller (and aerial machine) design is this: "The normal status of propelling (and of sustaining) surfaces should be in the position of maximum efficiency." The observance of this rule disqualifies the class of propeller last described.

It may be remarked, and it is only stating a fact, that few experimenters have devoted more time and careful attention to aerial propeller design for many years past than the writer of this article.

This has enabled him to produce that which has proved to be the most efficient aerial propeller of any now obtainable, even exceeding his most hopeful expectations.

This propeller was subjected to a systematic course of testing, and has the following characteristics:

(1) The highest efficiency yet recorded.

(2) An exceedingly light and strong structure of steel.

(3) The essential design lending itself most satisfactorily to such structure.

(4) Minimum radii of centers of pressure and mass.

(5) Reduced driving torque, and centrifugal stresses due to the above.

(6) Extreme simplicity of design.

(7) Displacing the air in a solid column (no centrifugal loss).

The propeller tested was of 6 feet diameter, and as little as one brake-horse-power sufficed to drive it at 370 revolutions per minute, the carefully weighed thrust at this speed was 26½ pounds. The volume of air displaced was 40,000 cubic feet per minute, and the linear velocity of air column was 1,400 feet per minute. Let it be borne in mind that this was at a speed of only 370 revolutions per minute, a low speed for a 6-foot propeller of this type.

As may be gathered from the foregoing general description, the design of this propeller is an entirely "new departure," comprising several features all conducive to the above high efficiency and satisfactory results generally.

The many inquiries that have come to hand from all quarters for this propeller are gratifying evidence that it is much needed. Indeed, it is now a widely recognized fact that the aerial propellers hitherto obtainable and now in use are lamentably inefficient. It is practically admitted that the recent aeroplane successes on the Continent (not including Wilbur Wright's) were achieved *in spite of very poor propellers*, and at the cost of that which was really redundant power and weight, since the propellers wasted fully half the power applied.

With a view to the more speedy consummation of legitimate practicable flight there is now probably no more promising expedient than the offering of a substantial prize for the most efficient aerial propeller, to be determined by competitive trial and test.

It will be obvious that the extravagant proportion of power now necessarily carried on aeroplane machines necessitates also a larger, stronger, and heavier machine, as a whole, for a given passenger-carrying capacity, allows no adequate margin for a sufficiency of fuel for continued flight, nor even for radiator and a water supply for cooling the motor. Added to this there is the increased difficulty and risk of managing and maneuvering a larger and cumbrous machine, and greater resistance to its propulsion. All these troubles

arise from the use of a poor propeller; the vital importance and imperative need of a really good one before we can perform flights *of any useful continuance* must be apparent to all who have given any thought to this interesting and fascinating subject.—*Aeronautics.*

THE ADVANTAGES OF RICH MIXTURES IN CONCRETE CONSTRUCTION.*

By E. S. LARNED.

ONE has only to see concrete, of proper proportions and good materials, such as 1 cement to 3 sand and 5 or 6 stone, mixed, to marvel at the wonderful binding qualities of the cement when he observes this mixture at the end of a few days; he will note, however, that the cement must be spread out pretty thin to fill the interstices of the sand and coat the surfaces of the individual grains three times in volume the amount of cement used. If the sand, however, be poor by reason of its geologic origin, mineral composition, or decomposition, or because of excessive fineness, or its content of fine material of a non-siliceous nature, then it is useless to expect good results of such proportions as 3 of sand to 1 of cement, and only careful analysis and test of the sand will enable us to judge as to whether it should be used at all, and, if so, in what proportions to attain the desired results within the required working limits of 7 or 28 days.

The general tendency in all reinforced concrete construction in the best practice is toward richer mixtures, particularly for column, beam and slab construction. The economy and logic of this is readily seen.

1. It makes possible the more economic handling of forms.

2. It is a safeguard against the dangers of average poor sand.

3. It means added strength and insures closer and more perfect contact with the steel.

4. It reduces to a minimum the personal equation in mixing and placing the concrete, the latter operation sometimes called "unmixing."

5. It means better fireproofing in that the aggregate is better covered and protected.

6. It is denser, stronger and more waterproof.

7. The difference in cost per cubic yard of concrete is nominal and much less than appears by reason of the advantages under Nos. 1 to 6.

The actual difference in cost of cement alone, per cubic yard of concrete, is given below, the assumed cost of cement being $1.50 per barrel net:

Proportions.	Cement required. Bbls.	Cost of cement per cu. yd.
1 : 1½ : 3	1.90	$2.85
1 : 2 : 4	2.48	2.22
1 : 2½ : 4	1.38	2.07
1 : 3 : 5	1.14	1.71
1 : 3 : 6	1.02	1.53

We are all reminded in this connection of the small percentage cement bears to the total cost of the completed work; in other words, if reinforced concrete in building construction could be figured at as low an average cost as $20 per cubic yard, the percentage cost of cement would be as follows for the several proportions given:

Proportions.	Cost of cement, Percentage of total. Per cent.
1 : 1½ : 3	14
1 : 2 : 4	11
1 : 2½ : 4	10
1 : 3 : 5	8½
1 : 3 : 6	7½

THE HYGROSCOPIC POWER OF COKE.

Next to the percentage of ash, the moisture content of coke is a most important feature in connection with the use of this fuel for blast furnace and foundry purposes, experience having shown that its usefulness diminishes considerably as the proportion of moisture increases. The taking of coke samples for analysis is a somewhat difficult operation, and consequently the figures obtained on analysis may differ to a large extent. For instance, in a case where the coke was found at the cokery to contain an average of 6.8 per cent moisture, the analysis made by the purchaser gave the mean value 10.6 per cent, the figures in another case being 5.5 per cent and 12.6 per cent respectively. Now, seeing that great care is taken in quenching the coke at the works, and that it is usually

sent out quite hot, one would expect the purchaser to find a lower percentage of moisture in it than that given by the cokery analysis, and the difference cannot be accounted for by attributing it to the effect of rain during transit. O. Strohmayer gives the following particulars of investigations carried on by himself for the purpose of ascertaining the capacity of perfectly dry coke to absorb water. A sheet iron cylinder, measuring 42½ inches in height and 36 inches across, the tare of which was 649 pounds, was filled as quickly as possible with broken coke just discharged

from the oven (before quenching) and weighed, the gross weight being 129 pounds and the net weight of the contained coke 638 pounds. The coke was next quenched, the vessel being filled with water to the brim, and replenished as fast as it was absorbed into the pores of the coke, until the liberation of air bubbles ceased. The weight was then found to be 2,560 pounds decreasing to 1,617 pounds on the water being allowed to drain off. The calculation of the volume occupied by the coke and of the water drained off showed the space occupied by cavities to be 54.9 per

cent of the total. The weight of water absorbed by the coke was 330 pounds or 34 per cent of the weight of the wet coke, and the total porosity of the coke was ascertained to be about 44 per cent, the density of the lump coke being determined as 0.85, and that of the coke substance as 1.52. This simple practical method is considered to furnish data of sufficient accuracy for working purposes, and more reliable for that object than the examination of small quantities in the laboratory.—Translation from Stahl und Eisen, in The Colliery Guardian.

DIAGRAM OF ELECTRIC WAVE-LENGTHS.*

THE SIMPLIFICATION OF CALCULATING WAVE LENGTHS.

BY W. W. MASSIE.

WIRELESS telegraph engineers and operators are frequently confronted by the problem of determining electric wave-lengths with certain known capacity and inductance in circuit or of ascertaining the capacity and inductance required to produce a certain wave-length. To eliminate the necessity of repeated calculations the accompanying diagram, shown in Fig. 1, has been made.

The curves of the diagram are based on the following well-known formula:

$$C = \frac{\lambda^2}{4\pi^2 V^2 L}$$

where

C = capacity,
λ = wave-length,
L = inductance,
V = velocity of light = 300,547 per second,

which can be written:

$$\lambda^2 = 4\pi^2 V^2 LC,$$
$$\text{or } \lambda^2 = KLC,$$

in which K is a constant having the value indicated. From the last formula it is seen that a curve plotted to rectangular co-ordinates showing the relation between L and C for a constant value of λ will be an equilateral hyperbola.

To obtain accurate readings, and at the same time to minimize the size of the paper, the curves were plotted as illustrated in Figs. 2, 3, and 4. Fig. 2 shows the curve in its natural form. Fig. 3 shows the curve with section C folded over B. Fig. 4 indicates both A and C folded over B. At first sight the curves, laid out in this way, appear somewhat complicated, but with a little practice values can be easily and accurately read to five significant figures.

Since, for example, a wave-length of 500 meters re-

readily be seen that the range and values are not confined to those given in the diagram, but can be varied to an unlimited extent as the value of C or L can be increased or decreased any number of decimal places
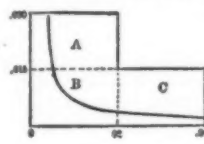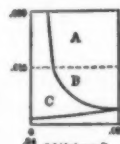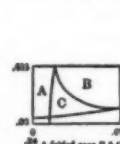

FIG. 2.   FIG. 3.   FIG. 4.

METHOD USED IN PLOTTING THE CURVES.

if in doing so the opposite factor is decreased or increased a corresponding number of decimal places. The wave length can also be varied any number of decimal points if the decimal point in C or L is correspondingly changed two places for each one in the wave-length, as shown by the formula above.

INFLUENCE OF TEMPERATURE ON RADIO-ACTIVE TRANSFORMATIONS.

As ALL chemical reactions are affected by temperature, a similar effect on radio-active transformations was sought soon after the enunciation of Rutherford's hypothesis. If heat results solely from irregular movements of molecules and within them, in which movements each atom remains invariable, no influence of heat or temperature on radio-active atomic transformations can exist. Conversely, if these transformations are found by experiment to be dependent on the temperature, we must either abandon Rutherford's hypothesis or admit that movements of the

the length of that period. His experiments prove clearly that radio-active processes are influenced by the temperature, the transformations of the emanation, radium A, radium B, and radium C being accelerated by increase in temperature. The effect is limited to the period of heating and the substances regain their original rates of transformation on cooling. The phenomena exhibited by radium emanation, in particular, appear to indicate that the emanation is not a homogeneous gas.

EXPLOSION GAS TURBINE OR COMBUSTION GAS TURBINE?

THE question which of these two types of turbine offers the greater practical possibilities seems important enough to deserve to be determined by calculation, says Dr. Phil. Wegner-Dallwitz in an article translated by the Electrical Review from Die Turbine. Whenever reference is made to a gas turbine, it is usually a combustion turbine, although published calculations show that, with the technical means at present available for its construction, the practical possibilities of this engine are very poor, while an explosion turbine can already be constructed which, though its heat economy may not be brilliant, can compete with the steam turbine, particularly in view of its greater simplicity (absence of the steam boiler). In the present article the combustion turbine is dealt with. The operation of such an engine is briefly as follows: Air and gas of a pressure equal to about that of the atmosphere and also of about the same temperature are compressed by pumps to a higher pressure, with an eventual rise in temperature, and are pressed into a combustion chamber, where the gas is burned by aid of the air in such measure as it is delivered by the pump, but so that the pressure in the chamber is not changed by the combustion process and the resulting heat and expansion. The inflow of gas is offset by an equally great outflow. The combustion raises the temperature of the chamber contents and causes them to expand through Laval nozzles to a lower pressure and temperature, whereby they attain a certain velocity with which they flow into any desired turbine system and perform work. The practicability of the combustion gas turbine is largely dependent on the efficiency of the compressor. It seems that only a turbine compressor, which rotates on the same shaft as the gas turbine, can be considered. A compressor of this kind by Parsons has been reported, which is said to compress gases to 1.4 atmospheres with an efficiency of sixty per cent. But it is not indicated whether this figure refers to adiabatic or isothermal compression. In technical circles generally the statements concerning this high efficiency are regarded skeptically. But even assuming this high compressor efficiency to be possible, and taking into account the thermal efficiency of the combustion process, the author reaches the following conclusions: If we are limited to adiabatic compression, the thermal efficiency of the combustion gas turbine at low pressures will be extremely small, and even at the high combustion pressure of fifty atmospheres it will be only 3.4 per cent in spite of the high compressor efficiency. If it should become possible to approach the compression curve to that of the isothermal, then the efficiency will rise to utilizable values at the higher combustion pressures. With a pressure of ten atmospheres in the combustion chamber and isothermal compression the absolute efficiency will be twenty-one per cent. Such a turbine would, therefore, be capable of competing with other engines, that is, if the compression could be effected with an efficiency of sixty per cent. If we figure only with the Parsons compressor under the assumption that the efficiency of sixty per cent really refers to isothermal compression, a combustion turbine could be constructed that would work with a thermal efficiency of three to eight per cent. Such a turbine could not be put on the market.
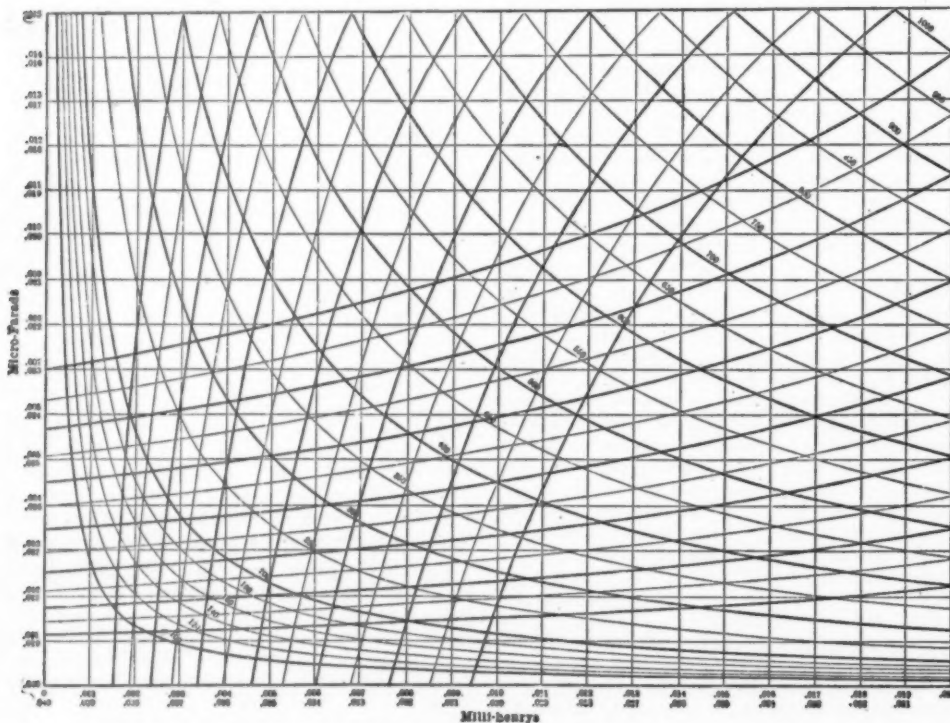
FIG. 1.—DIAGRAM SHOWING WAVE LENGTHS IN METERS FOR VARIOUS CAPACITIES AND INDUCTANCES.

quires 0.010 m. h., with 0.007 mfd., or 0.100 m. h. with 0.0007 mfd. or 0.001 m. h. with 0.07 mfd., while a 5,000-meter wave requires 0.10 m. h. with 0.07 mfd., or 1.0 m. h. with 0.007 mfd., or 0.01 m. h. with 0.7 mfd., it can

ultimate particles that compose the atom also constitute heat. W. Engler has recently made a study of the phenomena produced by heating radium B, radium P (induced radio-activity) and radium emanation, observing the rapid changes that may take place at the end of the period of heating, and the effect of

SOME NEW FRENCH TOYS.

EXHIBITS AT THE RECENT LÉPINE EXPOSITION.

JOINTED ANIMALS.—At the annual exhibition of toys recently held in Paris several exhibitors showed realistic or grotesque animals cut out of flat wood, in the style introduced three years ago by the celebrated illustrator Caran d'Ache, but with heads, ears, legs, tails, and even the front and rear halves of the trunk made separate and assembled by joints, so that the

JOINTED ANIMALS.

THE FOX AND
THE CROW.

THE WOLF AND
THE STORK.

animals can be placed in a great variety of attitudes. Many of these jointed animals are decorated in pyrogravure in an artistic manner which adds to their realism. This decoration might be left as a pastime to the children. Some very effective groups of animals, illustrating Lafontaine's fables, were also exhibited.

The Trained Elephant.—In this amusing and ingenious toy the figure of an elephant erect upon its hind legs, apparently balances itself on a barrel or drum, which it causes to roll by the movements of its feet. The drum, however, does not turn but only oscillates slightly about a mean position. The rotation is confined to the two loose ends, or covers, of the drum which are rigidly attached to an axis which passes freely through the drum, and are turned by a spiral spring concealed between one of the covers and the inner head of the drum and attached by one end to the drum and by the other end to the axis and covers. The opposite end of the axis bears an escape wheel, similarly concealed between the drum head and the loose cover. The pallet of this escapement is connected with a horizontal axis which passes
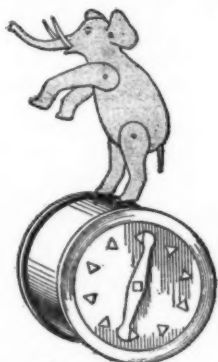
THE TRAINED ELEPHANT.
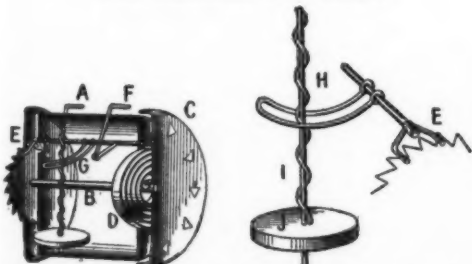
MECHANISM OF THE TRAINED ELEPHANT.

C. Loose cover. B. Axis of rotation. D. Driving spring. E. Escape wheel. F. Lever attached to horizontal escapement axis. G. Fork. H I. Vertical escapement axis with spiral wire. J. Flywheel. A. Arm at end of vertical axis.

through the upper part of the drum, parallel to the axis of rotation. This escapement axis carries a fork which engages with a wire wound spirally on a vertical axis, which bears a heavy wheel near its lower end. Hence the oscillations of the horizontal escapement axis are communicated to the vertical axis and

moderated by the inertia of the flywheel, which also serves, by its weight, to prevent rotation of the drum. The vertical axis passes through the upper surface of the drum and terminates in a horizontal arm, to the end of which one foot of the elephant is pivoted. The other foot is attached to a lever connected rigidly with the horizontal escapement axis, and oscillating with it. Hence the elephant both oscillates forward and backward and turns to right and left as the drum advances on its rolling covers. Any other figure may be substituted for that of an elephant, and if the figure is jointed it can be made to assume the most grotesque and apparently hazardous attitudes, without being in any danger of falling.

The Ball Trap.—The ball trap is a brass tube bent into the form of a semicircle and provided with two handles, by which it can be grasped. A ball is placed

THE BALL TRAP.

in the tube, which the player manipulates so as to throw the ball high in the air and catch it, on its descent, in the end of the tube opposite the end from which it was thrown. The difficulty may be increased by placing several balls in the tube at once and endeavoring to throw and catch them singly, in pairs, etc. A game, which offers abundant opportunity for variations, may be arranged among several players, each of whom is required to perform, in his turn, the same series of feats with the trap and balls.

A Magazine Popgun.—The piston of the magazine popgun ends in a coil of wire into which the thumb can be firmly fixed, while the first and second fingers are inserted in a loop of wire attached to the barrel, so that the gun is operated with one hand, the piston being pushed forward in the barrel by closing the hand and being pulled back by opening the hand. Above the barrel is the magazine cylinder, which is charged with twenty disks of cardboard pressed together by a spiral spring. When the piston is drawn

THE MAGAZINE POPGUN.

back as far as it will go, one of these disks falls into the barrel of the gun. The thumb and, fingers are then brought together, causing the piston to advance, pushing the disk before it, until the latter reaches the muzzle of the gun, which it fits exactly. The piston is then drawn back by opening the hand, causing a second disk to fall into the barrel, immediately in front of the piston. When this second disk is pushed forward, by closing the hand, the air imprisoned between the two disks is compressed until the disk at the muzzle is expelled, with a loud report, but the movement of the piston is continued until the second disk is deposited at the muzzle, ready to be expelled at the next shot, with the aid of the third disk. So by alternately opening and closing the hand, the twenty disks are expelled in rapid succession.

The Comet.—The comet is a light rod bearing a shuttle-cock at one end and a star-shaped piece of india rubber at the other. It is thrown into the air with the aid of an implement resembling a two-pronged
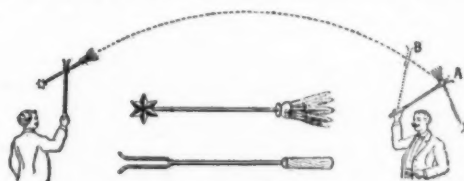
THE COMET.

fork, the interval between the prongs being large enough to admit the rod but not large enough to allow the star or the shuttle-cock to slip through. The comet describes a parabolic curve, with the star, or head, in advance, and is caught on another fork in the hands of the second player. The game is quite as interesting as the ordinary game of shuttle-cock and affords greater opportunity for exercise and the development of skill. It should be played out of doors, as the comet's flight may be made both lofty and far reaching.

Looping Bill.—In this device, which is one of a numerous class, a turn of a crank causes a ball to roll half way round a vertical circular track and fall through a gap in the inner wall of the track, at the top of the course, into one of a row of numbered pockets, or into a single pocket placed above the row, which is particularly difficult to attain and bears a correspondingly high number. If the handle is turned too violently the ball passes by the gap and entirely round
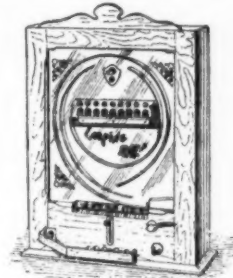
LOOPING BILL.

the track to the starting point, and is counted out. Each player, in succession, throws the same number of balls, and the numbers of the compartments which he succeeds in filling are added together to form his score.

A SIMPLE CALCULATOR.

THE accompanying cuts, reproduced from Der praktische Maschinen-Konstrukteur, show a rather interesting and ingenious calculator of a simple and cheap design, intended for rapid multiplication. The construction is easily comprehended directly from the cuts. There are five stationary slides, provided with numbers from 1 to 99, and between each of these rows of numbers there are nine movable slides which are numbered at the ends, 1, 2, 3, 4, etc. These movable slides are provided with figures, placed in a cer-
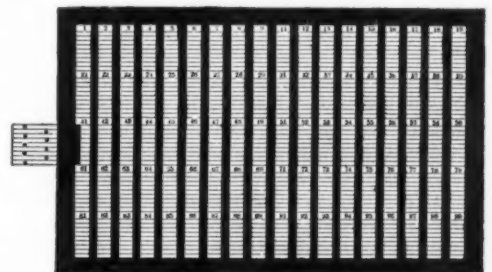
FIG. 1.—CALCULATOR FOR RAPID
MULTIPLICATION.

tain way, so that, by setting the slide, as indicated in Fig. 2, the product of the number on the stationary slide and the number at the end of the movable slide can be read off at once; thus, for instance, 4 × 44 is 176. In the case in Fig. 2, the number 6,543 is to be multiplied with any of the numbers on the stationary slide. The product of each of the figures in 6, 5, 4 and 3 times 44 will be found directly under 44, as 132, 176, 220, and 264; the movable slides being set in proper order, all that is necessary to get the multiplication is to add, the same as in ordinary multiplication, getting the product 287,892. It is, however, not necessary that the one number with which another is multiplied should have only two figures. It is possible to figure with factors having four figures a great deal easier than by ordinary multiplication. Take a case, for

FIG. 2.—METHOD OF USING THE
CALCULATOR.

instance, of 6,543 × 4,546. In this case, 4,546 is divided up in two parts, 45 and 46, and we have:

$$6543 \times 46.. = \ 300978$$
$$6543 \times 45.. = 294435$$

$$29,744,478$$

The products of each part of the number 4,546 with 6,543 are found directly on the scale in Fig. 2, by simple addition, and the time required for multiplication is but a fraction of that ordinarily necessary, if we multiply in the usual way.

RADIOACTIVE ELEMENTS.*

THEIR NUMBER AND THEIR PROPERTIES.

BY A. T. CAMERON.

No FEWER than twenty-four new elements have been discovered by radioactive methods; uranium and thorium were known long before their activity was observed. Of these twenty-six elements, five are said to be *rayless;* in them no activity has been detected by the instruments in use at present. The others emit one or more kinds of ray; nine or ten give α particles alone. An appreciable life-period is possessed by nine only—uranium, thorium, radium, polonium, radiolead, mesothorium and radiothorium, actinium, and probably ionium. The remainder are none the less true elements, although their short life may never permit them to be examined by other than radioactive means.

If the recent work of Boltwood is correct, and ionium is the true intermediate product between uranium X and radium, these twenty-six elements fall naturally into three large groups, namely, the elements uranium, thorium, and actinium, and their respective disintegration products. Using Rutherford's method of classification in a slightly modified form, the elements can be grouped as shown below. Only the atomic weights of three—uranium, radium, and thorium—are known with any certainty. If the α particle is a helium atom (of atomic weight 4), then the atomic weights of the other elements, calculated by deducting 4 for each α particle evolved, may approximate to those given in brackets. The present state of our knowledge does not allow any stress to be placed on this hypothesis. In the table Ur = uranium, Th = thorium, Ra = radium, Act = actinium.

The nomenclature of the elements is due to Rutherford; his original idea was to name the first derivatives so as to show their parentage; hence Ur X, Th X, Act X (ex-uranio, ex-thorio, ex-actinio). The discovery of radiothorium and radioactinium upsets this system. It will be observed that each group contains one gas or emanation; the elements derived from it are named in order of formation A, B, C, and so on. The graphic representation in the last column, due to Rutherford, illustrates the method of disintegration, the atomic contractions due to loss of α particles being considerably exaggerated in order to emphasize the theory. The brackets show those elements which differ in mass content by not more than one electron.

A short account of the individual elements will now be given, in the order shown in the table.

Uranium was discovered by Klaproth in the mineral pitchblende in 1789. It is of comparatively rare occurrence, and widely scattered. The composition of uranium minerals varies largely; many are complex silicates, phosphates, or arsenates. Pitchblende and uraninite consist largely of uranium oxide, and contain from 50 to 80 per cent uranium. The metal was isolated by Peligot in 1842 by the action of potassium on the fused oxide. Thus formed it is a black powder. In the ordinary metallic state it closely resembles iron and nickel. Heated to redness it burns brilliantly. It dissolves in dilute acids, with evolution of hydrogen; combines directly with chlorine, and, on heating, with sulphur. Its atomic weight is 238.5: it is thus the heaviest metal yet isolated. A great number of its compounds have been prepared. The discovery of radioactivity by Becquerel, in 1896, was made with these compounds; it has been shown that the metal is also radioactive. The life of uranium is extremely great. Its half period is many millions of years.

In 1900 Sir William Crookes showed that when excess of ammonium carbonate is added to a uranium solution until the uranium precipitate has all redissolved, a light cloudy precipitate remains: this contains all the photographic activity; the separated uranium is without effect on a photographic plate (α rays do not affect a photographic plate; uranium gives off α rays only); Crookes called the new product uranium X. The precipitate consists largely of impurities from the uranium salt, and insufficient uranium X has been obtained to give a distinctive spectrum. A mixture of ether and water effects a partial separation. The ether layer contains most of the photographic or β-ray activity. Becquerel effected a separation by adding barium chloride and precipitating the barium as sulphate; uranium X is carried down along with it. Recently (in 1906) Moore and Schlundt have described further methods of separation. When crystallized uranium nitrate is dissolved in acetone, or several similar organic solvents, the slight precipitate which remains contains most of the uranium X. Complete separation is effected by adding moist ferric hydrox-

ide to such a solution; the hydroxide carries down all the active matter. Moore and Schlundt state that uranium X gives both α and β rays; 34 per cent of the activity is due to the α rays. Levin in 1907 obtained the figure 8 per cent; in a later paper he states that no α rays are produced, the mistake arising from the presence of β rays of small velocity. The question has not yet been decided. Uranium X has a half-life period of twenty-two days. In less than a year it has disintegrated almost completely. Into what has it changed?

Ever since Madame Curie succeeded in obtaining radium from uranium minerals, and the theory of

to actinium nor its emanation. Rutherford separated the actinium from solutions of commercial uranium nitrate, and by passing ammonia and sulphureted hydrogen gases through the actinium solution, he effected the separation of a new radioactive substance, which he considered to be the actual intermediate product between uranium X and radium. Boltwood confirmed this result. He found this new element emits α rays (actinium is rayless) which are very easily absorbed, and β rays of small penetrability. The activity is of the same order as that of radium. He suggested the name ionium. Hahn has confirmed his conclusion by a different method.

ELEMENT.	ATOMIC WEIGHT.	HALF-LIFE PERIOD.	NATURE OF EMITTED RAYS.	EXAGGERATED GRAPHIC REPRESENTATION
First Group :				
Ur	238·5	—	α	
Ur X	(234·5)	22 days	αβγ	
Ionium	(230·5)	—	αβγ	
Ra	226·5	1300 years or 164 ,, }	α	
Emanation	(222·5)	3·8 days	α	
Ra A	(218·5)	3 minutes	α	
Ra B	(214·5)	21 ,,	rayless	
Ra C	(214·5)	28 ,,	αβγ	
Ra D	(210·5)	40 years	rayless	
Ra E	(210·5)	6 days	βγ	
Ra F	(210·5)	143 ,,	α	
Inactive Product	(206·5) Cp. lead = 207	—	rayless	
Second Group :				
Th	232·5	—	rayless	
Mesothorium	(232·5)	5·5 years	β	
Radiothorium	(232·5)	737 days	αβγ	
Th X	(228·5)	4 ,,	α	
Emanation	(224·5)	53 seconds	α	
Th A	(220·5)	11 hours	slow β	
Th B	(220·5)	} 55 minutes	} αβγ	
Th C	(216·5)			
Inactive Product	(?)	—	rayless	
Third Group :				
Act	?	—	rayless	
Radioactinium		19·5 days	α	
Act X		10·2 ,,	α (β?)	
Emanation		3·9 seconds	α	
Act A		36 minutes	rayless	
Act B		2·15 ,,	αβγ	
Act C		?		
Inactive Product		—	rayless	

disintegration was put forward, it has been considered highly probable that radium is a descendant, in perhaps the third or fourth generation, of uranium itself. Some experiments of Soddy in 1904 gave the first proof of this statement. He took about two pounds of uranium nitrate, dissolved it in water, and repeatedly added barium solution, precipitating the barium as sulphate. In this way the solution was practically freed from radium, which is precipitated along with the barium sulphate. In 567 days the solution contained more than one hundred times as much radium as it did immediately after this treatment. This radium was identified by the decay rate of its emanation. The actual amount of radium observed was only one-thousandth of what it should be on the assumption that uranium X was the parent of radium. Soddy postulated one or two intermediate products. Boltwood criticised his method of procedure but afterward confirmed his results. In 1906 he suggested that the intermediate product was actinium. Soddy and Mackenzie, and also Rutherford, showed that this was impossible, pure uranium nitrate neither giving rise

Radium was discovered by Madame Curie in 1898. Her method of procedure has been indicated. Thoroughly examining the different group precipitates in an analysis of pitchblende, she found that the barium group precipitate was strongly active. This activity could be completely separated along with barium sulphate. Final separation was effected by recrystallizing the barium as chloride; radium chloride is slightly less soluble and separates in the first fraction. In this way crystals were finally obtained nearly two million times as active as uranium. The activity was too great for comparative measurements; the final fractions were tested for purity by estimating the amount of barium spectroscopically.

Giesel showed later that the separation could be effected more conveniently by recrystallizing the bromides; the difference in their solubilities is greater than in those of the chlorides.

Radium continually gives rise to a gas, the emanation from radium, discovered by Dorn in 1900, and no 'intermed'ate product has yet been detected.

When any substance is exposed to the action of the

emanation it becomes coated with an intensely active deposit. This was first observed by M. and Mme. Curie in 1899. It is known as the active deposit of rapid change, and has been found to consist of three consecutive products, radium A, B, and C. The whole activity decays to half value in 28 minutes, but the decay curve is very irregular. Studies of the rates of decay of the different rays led to the analysis into three separate elements. All three are soluble in strong acids, and volatile at a white heat. B is volatile at the lowest temperature, and can be thus partially separated.

In 1903 the Curies also observed that substances which have been covered with this active deposit do not lose all their activity after even a prolonged period. Giesel confirmed this. Rutherford found that the activity increases during several years. It is due to the active deposit of slow change, which has been resolved similarly into three consecutive products, radium D, E, and F.

Radio-lead (or radium D) was obtained by Hofmann and Strauss in 1901. The lead obtained from pitchblende was strongly and permanently radioactive—hence the name radio-lead. In 1904 Hofmann and co-workers showed that the lead itself is not radioactive, but gives rise to active products separable by chemical means; the inactive lead slowly regains activity. It therefore contains an inactive element which disintegrates slowly into active products. Rutherford has proved fairly conclusively the identity of the rayless parent, the true radio-lead, with radium D, and of the active products with E and F. He found that the activity of the short-life deposit from radium practically vanished after two days; thereafter there was a very slow increase during eighteen months.

The new activity was due to both α and β particles. Two experiments showed the nature of the changes. A deposit on a platinum wire, after standing for some considerable time, was subjected to the action of heat. Below 1,000 deg. it was unaffected. Between 1,000 deg. and 1,050 deg. some part volatilized. It no longer gave off α particles, while the β-ray activity decreased rapidly, falling to half value in six days. During the same time α rays were emitted in slowly increasing amounts.

Clean surfaces of metallic bismuth placed for some time in solutions of the slow-change deposit removed 90 per cent of the substance emitting α particles. The bismuth thereafter emitted these α particles, activity decreasing somewhat slowly; the half-life period was 143 days. The β-ray activity of the solution remained unaltered by this treatment; after the bismuth was taken from the solution the latter commenced slowly to emit α rays.

A simple explanation is given by the assumption of three elements: radium D (rayless); E, giving β rays only; and F, giving α rays only. D is volatile below 1,050 deg.; E does not volatilize at that temperature. D is the parent of E, for after it has volatilized the amount of E rapidly becomes less. F volatilizes at 1,050 deg., for the wire loses its α activity. It is produced from E, for the α activity of the wire is slowly regained. F, alone of the three, is deposited on bismuth from solutions, and it is the element whose half-life period is 143 days.

Meyer and Schweidler consider that this hypothesis does not completely satisfy the peculiarities of the curve of decay. They suggest a further intermediate product (thus RaE, and RaE.).

Rutherford has shown the identity of polonium, radio-tellurium, and radium F. Polonium was the first radioactive substance discovered by Mme. Curie. The sulphide precipitate from acid solutions of pitchblende contained an active substance, which associated itself with bismuth. With this element its properties are so closely allied that it is impossible to effect a complete separation. Madame Curie repeatedly precipitated the nitric-acid solution by water. The precipitate contains most of the active material. Marckwald obtained the same substance by dipping a rod of bismuth or antimony in the active solution. These formed an intensely black deposit, chiefly tellurium, and very active; he named the active matter radio-tellurium. Dissolved in hydrochloric acid, all the tellurium was precipitated by hydrazine hydrochloride; the active matter remained in solution. By repeating the process, Marckwald obtained a few milligrammes of intensely active material.

There remains the question of the final product. Radium F decays at a moderately rapid rate. What becomes of it? Two lines of argument point to the conclusion that lead is formed. On the assumption that the α particle is helium of atomic weight 4, then, since α particles are given out by radium and four of its products, the atomic weight of the final product should be $226.5 - (5 \times 4) = 206.5$. Lead has the atomic weight 207, a very close agreement.

Again, Boltwood has shown that lead is present in all uranium-radium minerals, and the amount is greatest in the oldest—i. e., those in which the greatest quantity of uranium has disintegrated. This also

points to the fact that the lead is derived from uranium, and therefore from radium.

Thorium was discovered by Berzelius in 1828. It occurs chiefly in Ceylon, the recently discovered mineral thorianite containing more than 70 per cent of it. It is precipitated from solution by ammonia, and usually separated in the form of oxalate. The metal has been prepared as a gray powder; it burns brilliantly in air, and is easily dissolved by warm, dilute acids. The oxide ThO_2 is usually obtained by calcining the oxalate or sulphate. A large number of the salts have been prepared.

An account of the disintegration changes of thorium has been given elsewhere. It need only be mentioned here that the emanation is an inert gas strongly resembling the gases of the argon group, while the activity of radiothorium is several hundred thousand times that of thorium itself. Rutherford suggests that the final disintegration product of thorium may possibly be bismuth.

Actinium was discovered by Debierne in 1899, and independently as *emanium* by Giesel in 1902; it is precipitated with the group of cerium earths, and is closely allied to lanthanum. It is many thousand times more active than thorium; although it strongly resembles that element, yet all the products of the two have entirely different decay rates—a sufficient proof of their separate identities.

Hahn, in 1907, succeeded in showing that actinium is rayless, its activity being due to its first product radio-actinium; this gives α rays only, corresponding to radiothorium. According to Giesel it resembles the alkaline earth metals, and can be precipitated from actinium solution by means of finely divided sulphur. It disintegrates into actinium X, independently discovered in 1905 by Giesel and Godlewski; the separation is similar to that employed for thorium X. The emanation was observed by both Debierne and Giesel; Godlewski proved that actinium X was its immediate parent. Debierne has recently noted the production of helium from this emanation; Giesel has confirmed the statement. The analysis of the active deposit from the emanation is in great part the work of Miss Brooks. Her work led to the recognition of actinium A and B; Meyer and Schweidler consider that C and D also exist.

So far we have no clue to the atomic weight of actinium. But it corresponds to lanthanum; in that case it either comes between radium and thorium, with an atomic weight of about 230, or has a greater weight than uranium. Actinium emanation most probably belongs to the argon series, in the periodic system, when it follows that radio-actinium corresponds to radium (it resembles the alkaline earth metals) and actinium X occupies the space below gold. With similar treatment of the thorium products we can postulate some such arrangement as the following for the higher members of the periodic system; it accepts the simplest hypothesis of disintegration—that it is accompanied by loss of mass.

Kr 87·8	Rb 85·4	Sr 87·6	T 89	Zr 90·6	Cb 94	Mo 96	—	Ru 101, Rh 103, Pd 106·5
...	Ag 108	Cd 112·4	In 115	Sn 119	Sb 120	Te 127·6	I 127	...
X 128	Cs 133	Ba 137·4	La 139	Ce, etc., 140-178	Ta 183	W 184	...	Os 191, Ir 193, Pt 195
...	Au 197	Hg 200	Tl 204	Pb 207 / Bi 208·5	←RaF→ / Bi 208·5	(RaE)←	(βRaD)→ / ?← / ?←	(RaC)←(RaB) ←(RaA)← / (ThC)←(ThB) ←(ThA)← / (AcrC)←(ActB) ←(ActA)←
Ra Em / Th Em / Act Em←	ThX← / ActX←	Ra 226·5 / Radioth← / Radioact←	Mesoth Act	Ionium← / Th 232·5	UrX	U 238·5		

There are several difficulties in the way of accepting such a scheme. For example, radium D has given no indications of any resemblance to the halogens; on the contrary it strongly resembles lead. Although such hypotheses must therefore be put forward very tentatively, we can scarcely evade the conclusion that many higher members of the series have almost coincident atomic weights, while there are several cases of at least two elements occupying one space in the table. Thus, considering the radium and thorium products alone, their emanations are both inert gases strongly resembling the argon gases. To move one a space higher in the series, the difference in their atomic weight must be at least 25. If the hitherto published chemical work on the atomic weight of radium is in any way near the truth, this cannot be the case. Similarly, radium F must have an atomic weight less than radium, and it closely resembles bismuth in all its properties. If the atomic weight of radium is 226.5, it seems certain that bismuth and radium F must occupy the same space. There are only two other possibilities. A somewhat similar table, put forward by Meyer and Schweidler in 1906, assumes that uranium contains in reality a second element of much greater atomic weight, about 260, and that radium has the corresponding weight 255. In the second place, disintegration may result in the combination of two or more atoms of the product, giving an element of higher atomic weight; in this case, the

active elements will not appear in consecutive series in the periodic table.

A $500 PRIZE FOR A SIMPLE EXPLANATION OF THE FOURTH DIMENSION.

A FRIEND of the SCIENTIFIC AMERICAN, who desires to remain unknown, has paid into the hands of the publishers the sum of $500, which is to be awarded as a prize for the best popular explanation of the Fourth Dimension, the object being to set forth in an essay the meaning of the term so that the ordinary lay reader can understand it.

Competitors for the prize must comply with the following conditions:

1. No essay must be longer than 2,500 words.
2. The essays must be written as simply, lucidly, and non-technically as possible.
3. Each essay must be typewritten and identified with a pseudonym. The essay must be inclosed in a plain sealed envelope, bearing only the pseudonym. With the essay should be sent a second plain sealed envelope, also labeled with the pseudonym, and containing the name and address of the competitor. Both these envelopes should be sent to "Fourth Dimension Editor, SCIENTIFIC AMERICAN, 361 Broadway, New York, N. Y."
4. All essays must be in the office of the SCIENTIFIC AMERICAN by April 1, 1909.
5. The Editor of the SCIENTIFIC AMERICAN will retain the small sealed envelope containing the address of the competitor and forward the essays to a Board of Judges, who will select the prize-winning essay.
6. As soon as the Board of Judges have agreed upon the winning essay, they will notify the Editor, who will open the envelope bearing the proper pseudonym and containing the competitor's true name. The competitor will be notified by the Editor that he has won the prize, and his essay will be published in the SCIENTIFIC AMERICAN.
7. The Editor reserves the right to publish in the columns of the SCIENTIFIC AMERICAN or the SCIENTIFIC AMERICAN SUPPLEMENT three or four of the more meritorious essays, which in the opinion of the judges are worthy of honorable mention.

The judges who will award the prize will be three in number, and all will be eminent American mathematicians. The names of the judges will be announced in a later issue of this journal.

IMPROVED HEALTH OF THE BRITISH ARMY IN INDIA.

MALTA fever has been practically stamped out since the doctors discovered its originating causes, and with the compulsory cessation of the use of goats' milk, which contained the fever germs, the number of admissions to hospital has dropped successively for three years from 643 to 161 and 11 cases.

The troops in India have benefited greatly from the improvement in medical science and from the increased knowledge of the doctors as regards sanitation. In the forty years between Waterloo and the Crimea campaign, according to Colonel Tulloch, nearly 100,000 Europeans perished in India from preventable causes. For the first half of this period the army numbered 25,000 men, and later was raised to 40,000. The terrible mortality, mainly in Bengal, was the result of a want of sanitary knowledge in the selection of cantonments. Apart from humane considerations, the monetary loss alone, irrespective of that of invalided soldiers, amounted to £10,000,000.

Formerly the most dreaded station was Mian Mir, the Lahore cantonment. There in 1879 the admissions per 1,000 men from fever alone were 3,427 and from all causes 4,700. Ten years ago the average of admissions was 2,000 per 1,000, but it has dropped gradually one or two hundred annually until last year, when it was 650 per 1,000. It is natural that the number of constantly sick in India should be higher than it is in the United Kingdom, and it is still double; but now those in command appreciate the financial as well as the humanitarian importance of the question.—Saturday Review.

THE process of nailing bones together in order to heal fractures has been employed in some cases in surgery, especially in the case of open fractures where the bones are invisible. At first nickel nails were used, which were of long conical form some four inches or less in length. These were driven into the two pieces of bone in order to hold them firmly in place. Generally two nails are placed side by side in order to make a more solid joint. The nickel causes no complications. Ivory and bone nails are also employed. They disappear, as they are absorbed by the tissues. It was also found that aluminium and magnesium nails are absorbed by the organism, for which reason these are preferred to the bone or ivory nails. Such operations are not frequent, and are necessary chiefly in the case of fractures which refuse to heal by the ordinary means.

CONCRETE PIER AT SANTA MONICA, CAL.

## THE SECOND CONCRETE PIER IN THE WORLD.

BY C. B. IRVINE.

Work is in progress at Santa Monica, Cal., on the construction of the first reinforced concrete pier to be attempted in the West, and the second in the world, so far as the engineers who designed it know. This pier is being erected by the municipality at an outlay of $100,000, and the experiment is being watched with much interest by cities, corporations, and transportation companies. Should the success that is anticipated be achieved, there would be a saving annually of many thousands of dollars to such companies as might replace their wooden piers and wharves with concrete structures, as it would not in time become necessary to replace the teredo-eaten piles of wood. Concrete piles will endure forever, so far as inroads on the part of the teredo are concerned.

This pier, which is to be 1,600 feet in length, is being built for the purpose of carrying the outfall pipe from the new sewer system. The piles, ranging in length from 14 to 72 feet, have a diameter of 14 inches for the shorter ones at the shore end and from that up to 22 inches at the deep water terminus. They are being molded near the site of the pier; and after being given ample time to season, they are
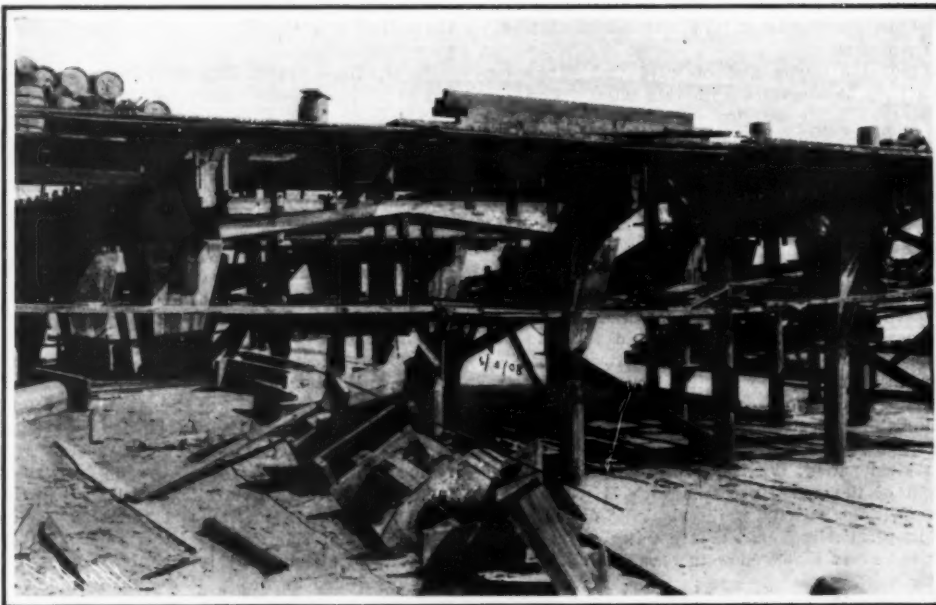
PILES IN PLACE, SHOWING BRACKETED HEAD, MOLD FOR GIRDERS AND STRUTS, AND FALSEWORK.
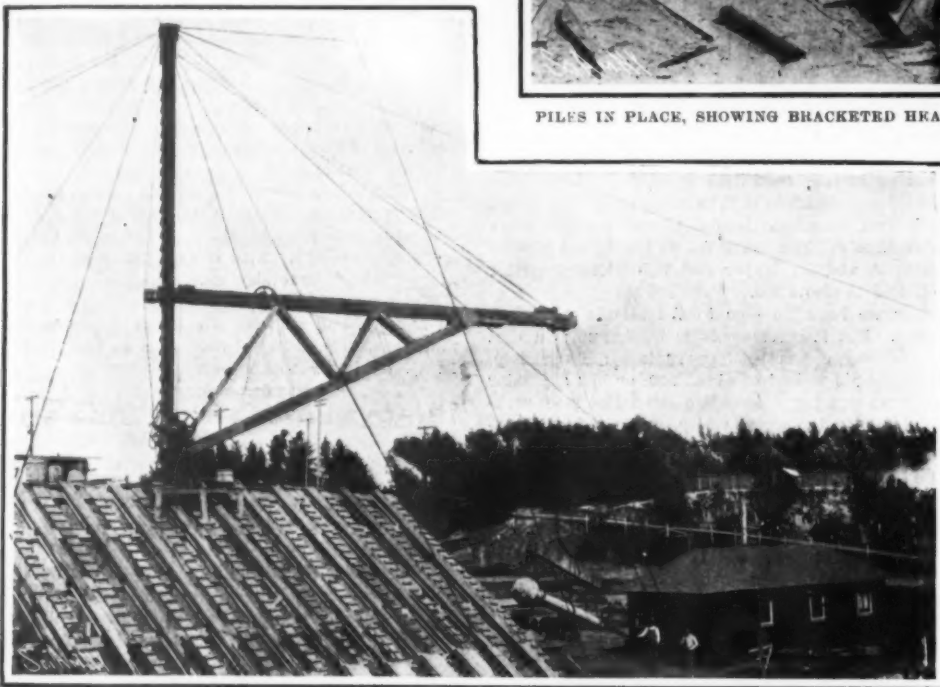
CONCRETE PILE (SHOWING BULB END) BEING HOISTED FROM THE MOLDS.

elevated to a tramcar, conveyed to the frame falsework, and lowered into the sea. Each of the piles is reinforced with from six to eight ¾- to ⅞-inch steel rods, arranged symmetrically 2 inches from the outside of the pile, and tied together at every 3 feet of their length with No. 14 wire to a 2-inch pitch. The piles are molded with a bulb point, and into this the lower ends of the rods are splayed. The upper ends of the rods extend through the bracketed heads of the piles, and are carried above the head to mesh into the reinforcement of the concrete girder and strut. Through the center of each pile runs a 2-inch jet pipe of iron, furnished with a coupling for hose connection in jetting. After the pile has been put in place, this pipe is filled with concrete. The piles are sunk in the sand for a distance of from 16 to 20 feet, by means of a water jet. The finishing touch consists of inclosing each pile in a jacket of No. 12 steel. These jackets are 9 feet long, and extend from 3 feet below the line of mean low tide to 6 feet above.

The longitudinal struts and girders are of reinforced concrete, bolted and meshed into the bracketed heads of the piles, by means of the steel rods. The pier is to have a width of 30 feet, and its asphalted floor will be 21 feet above the mean tide level. At the point where it is being built, the ocean bed is of sand and slopes seaward at an inclination of 2 feet in each 100 feet. Each trestle bent of the pier is made up of three piles, spaced 13½ feet from center to center.

The same year, 1847, in which Joule announced his views on energy before the British Association, Helmholtz, a youth of 26, read before the Physical Society in Berlin a paper on the same subject, entitled, "Die Erhaltung der Kraft." It was at first pronounced a fantastic speculation. The editor of Poggendorff's

Annalen, who in 1841 declined Mayer's paper, rejected Helmholtz's also. As Joule was supported by William Thomson, so Helmholtz was defended by his fellow-student Du Bois-Reymond, and by the mathematician C. G. J. Jacobi. Helmholtz's paper was published in pamphlet form in 1847. For a time it attracted little notice, but in 1853 some parts in it were vigorously attacked by Clausius in Poggendorff's Annalen. Later it subjected its author to bitter attacks from Eugen Karl Dühring and others, who accused him of being a dishonest borrower from his forerunner, Robert Mayer. In a publication of 1898, issued in Berlin, Dr. Thomas Gross does not quite accuse Helmholtz of plagiarism, but claims that Helmholtz did all he could to discredit Mayer. In my judgment both Dühring and Gross failed to establish their contentions. In the absence of clear evidence to the contrary we prefer to accept Helmholtz's own statement, as given in one of his lectures. Helmholtz says in one place, "The first who saw truly the general law here referred to and expressed it correctly was a German physician, J. R. Mayer, of Heilbronn, in the year 1842." Then he says, "I myself, without being acquainted with Mayer or Colding, and having first made the acquaintance of Joule's experiments at the end of my investigations, followed the same path."
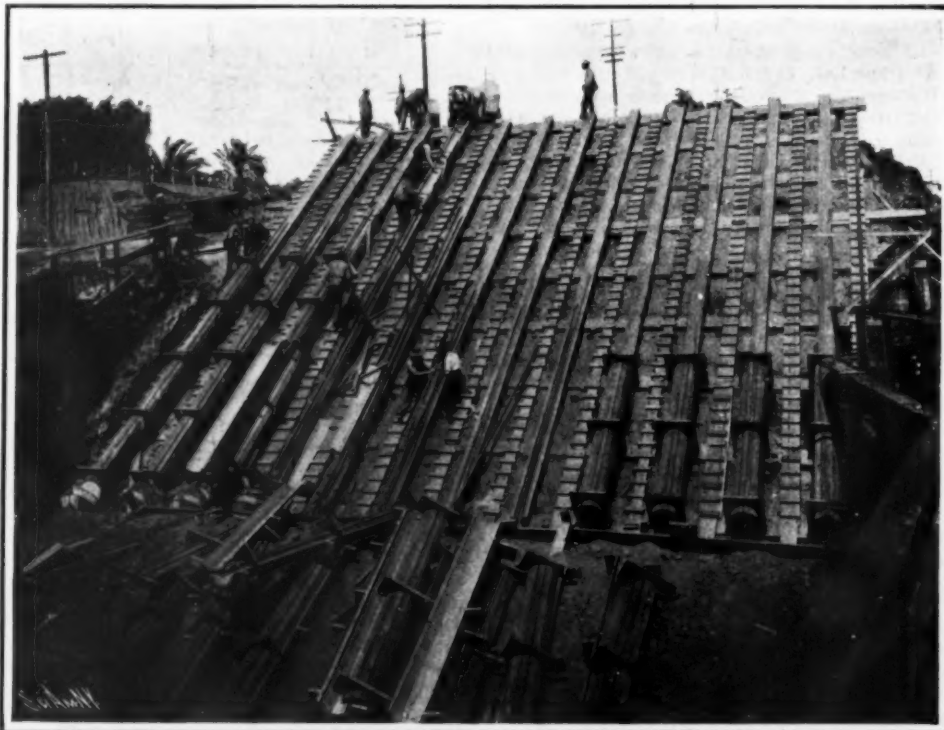
CASTING THE CONCRETE PILES IN INCLINED MOLDS.

CONCRETE PIER AT SANTA MONICA, CAL.

THE BROTAN LOCOMOTIVE BOILER.

A NEW ENGINE WITHOUT COPPER PLATES AND BRACES.

A LOCOMOTIVE boiler of the classical type is composed, in the first place, of a rectangular furnace, at the bottom of which is a grate on which the fuel is burned. This furnace, at least in Europe, is made of copper and is surrounded by a firebox, of almost exactly the same shape, which, however, gives sufficient clearance for the free circulation of water. The front of this firebox, which is made of soft steel, is connected by

and sixteen atmospheres or 240 pounds are used to-day in many locomotives, both French and foreign. It is owing, furthermore, to this increase of pressure, in connection with the improved utilization of the steam by the compound engine, that it has become possible to increase greatly in recent years the quantity of work done per pound of steam or, in other words, the power of the locomotive. But this incon-

testable advantage has brought with it certain serious inconveniences.

So long as the pressure on the boiler did not exceed ten atmospheres, the tube plates lasted twenty-five or thirty years. With the pressures now used, in consequence of the alternate expansion and compression of the bundle of tubes, there are produced breaks between the ends of the tubes and cracks at the angles of the tube plates, so that these plates have to be renewed in three or four years. Furthermore, the side plates, especially near the brick arches, deteriorate rapidly, and the braces which connect the plates of the furnace with those of the firebox are subjected to a bending stress by the unequal dilatation of the two walls, and hence become deformed. The holes through which these braces pass become enlarged, and give rise to leaks. It may be added that the strength of these copper braces diminishes greatly as the steam pressure, and consequently the temperature, increase. The copper braces have recently been replaced by braces composed of a special alloy or of a more rational form, but the results obtained have not been very satisfactory.

Another and still more important cause of deterioration of the furnace is the employment of fuel containing sulphur and of bad feed water. The copper of the furnace is attacked, and the heads of the braces are entirely corroded in a very short time. So, in certain sections of the Austrian State Railways, where highly sulphureted lignites are burned, the corrosion amounts to from 1/25 to 1/16 of an inch monthly. The copper furnaces had to be renewed in two years, at the expiration of which time the thickness of their
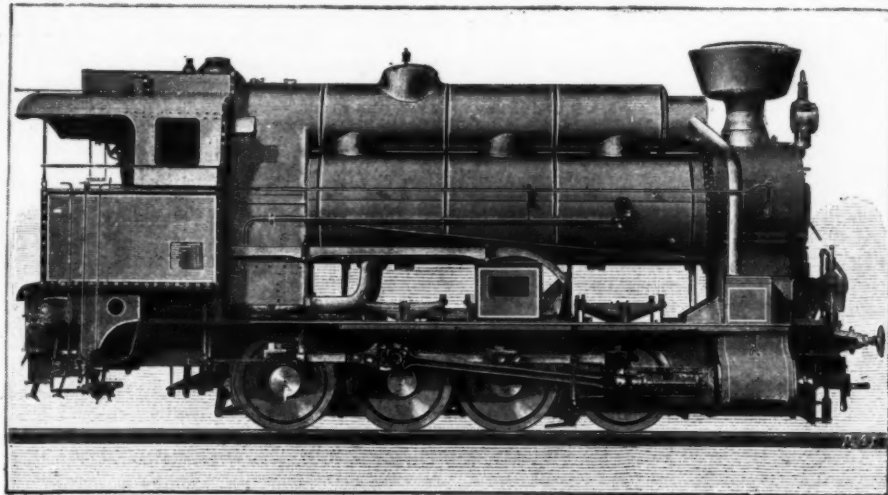
FIG. 1.—AN AUSTRIAN LOCOMOTIVE WITH A BROTAN BOILER.

welded plates with the cylindrical body of the boiler, which contains a bundle of tubes. The walls of the furnace and of the firebox, which are plane and consequently oppose little resistance to the pressure of the steam, are stiffened by braces, which are placed very close together and connect the two walls. The front plate of the furnace is thicker, and it is made rigid by the tubes which connect it with the back plate, and thus act as braces. The dome of the furnace is stiffened either by struts, which distribute the pressure over the side walls, or by tie rods connecting the dome with the cradle which forms the top of the firebox. The front plate of the furnace and firebox has an opening through which the grate is charged with fuel.

The furnace is provided with a brick arch, the object of which is to mingle the products of combustion. These gases then pass through the bundle of tubes to the smokebox in front and thence to the smokestack, in which terminates also the exhaust steam pipe which increases and regulates the draft. Under the influence of the hot gases in direct contact with the walls of the furnace and the tubes, the water of the boiler is converted into steam at a determined pressure, which is limited by the adjustment of the safety valve, placed in the upper part of the boiler, generally near the firebox.

Until about 1885 the pressure used in locomotives rarely surpassed ten atmospheres or 150 pounds. Since that date the pressure has been greatly increased,
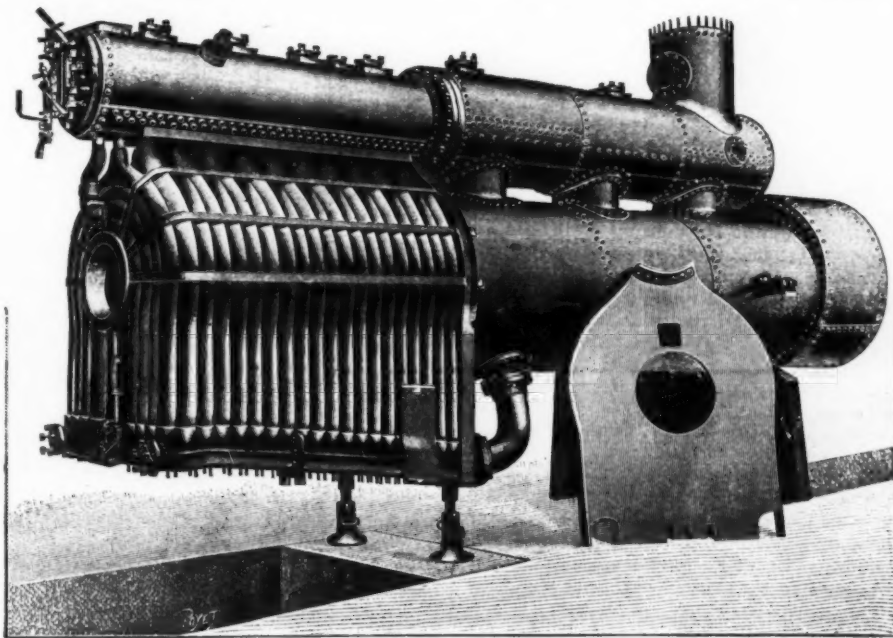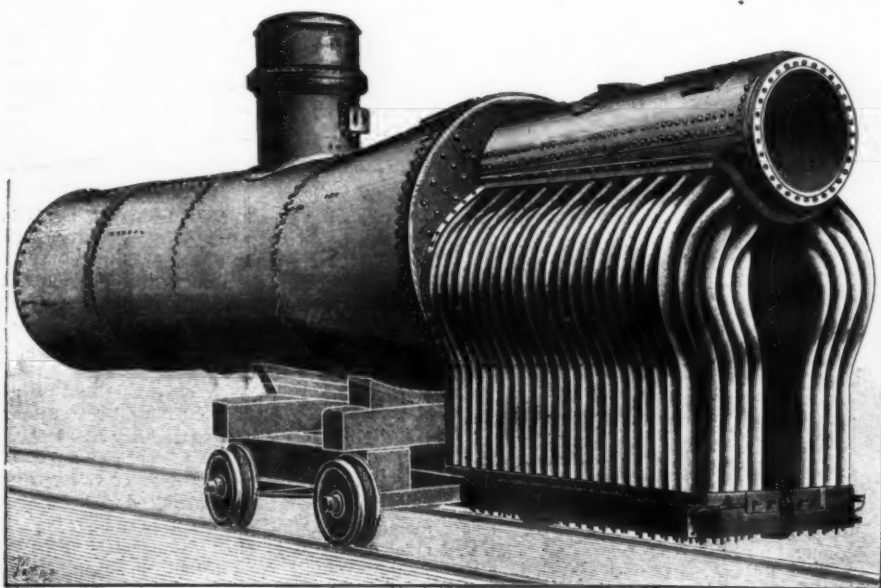

FIG. 3.—BROTAN BOILER WITH LONG COLLECTOR.

plates, which was originally 3/4 inch, had been reduced to 1/5 inch near the grate. The braces were loose in their holes. The same effects were noticed when the copper plates were replaced by plates of steel or iron.

In view of these grave inconveniences, which entail great expense for upkeep, and in view also of the advantages secured by the employment of high-pressure and compound engines, attempts have been made to suppress the copper plates and braces, which are the primary cause of this deterioration and increased expense. Among the boilers designed to this end we shall describe the one invented by Herr Brotan, Chief Engineer of the Austrian State Railways. The bottom of the furnace (Fig. 3) is formed of a tube of cast steel about 6 inches in diameter, which is connected with the lower part of the cylindrical body of the boiler by copper tubes. From each side of this tube of welded steel jointless steel tubes, 4 inches in diameter and 1/5 inch thick, rise, bend inward, and terminate in a cylindrical upper conductor, which extends over the whole length of the boiler, and is connected with the main body of the boiler below it by three large pipes. The back of the furnace is also provided in part with vertical tubes, and the voids left between these tubes are filled with fire bricks. The cylindrical body of the boiler, which is entirely similar to that of the ordinary boiler, terminates at each end in a tube plate, and is closely packed with smoke tubes. The level of the water in the boiler is about at the axis of the upper collector.

FIG. 2.—BROTAN BOILER WITH SHORT COLLECTOR.

THE BROTAN LOCOMOTIVE BOILER.

In these conditions, under the action of the heat derived from the products of combustion, a lively circulation of water is established from the cylindrical body through the tube which forms the frame of the furnace; thence to the upper collector, and from this back to the cylindrical body through the three large vertical tubes. Openings in the frame of the furnace and other necessary places permit the water tubes to be cleaned. A jacket of steel plates about half an inch thick surrounds the bundle of tubes. (Fig. 1.)

Fig. 2 shows a boiler of the same system, in which the upper collector, instead of extending over the entire length of the boiler, extends only over the furnace and terminates in the upper part of the tube plate. From this brief description it will be seen that the Brotan boiler does away with the principal causes of deterioration of the furnace, which have been indicated above. It eliminates the plane surfaces, braces, and tierods, which are frequent causes of fractures and incrustations. It suppresses rivets and joints on parts exposed to flame. With the Brotan boiler it is possible to obtain a rapid circulation of water, which is of advantage from the point of view of efficiency and freedom from incrustation. It is possible to attain high pressures with a minimum

danger of explosion. Cleaning and decrustation are easily accomplished. Finally, according to data given by the makers, for an equal heating surface it weighs no more than the ordinary boiler, and costs a trifle less.

The Brotan boiler was first applied in 1901 to a freight locomotive on the Austrian State Railways, burning a very highly sulphureted lignite. After a very hard service of more than three years, it was not necessary to replace any of the water tubes, and the furnace was in perfect condition. No corrosion or deformation of the tubes had been observed in the vicinity of the grate. In view of these gratifying results, the Austrian State Railways have adopted this type of boiler for a number of freight and passenger locomotives.

Various other railway companies have followed the example. Among these may be mentioned the Hungarian State Railway, the Russian lines from Moscow to Kazan, the Prussian Railways, the Swiss Government Railways, the St. Gothard, the South-Eastern Russian Railway, and the French Midi and Paris-Lyons-Mediterranean systems.

What conclusion is to be derived from these facts? Can the tubular boiler of Stephenson, which for more

than eighty years, in consequence of its elasticity and simplicity, was able to satisfy all demands made of it, satisfy the future demands of a service which is becoming more exacting, or must it give up the field to a new type of boiler, possibly less advantageous from certain points of view, but better adapted to increased pressure, more rapid evaporation, and consequently increased power?

The locomotive boiler is now at a turning point of its history, and it would be rash to predict the form which it will finally assume. We can only indicate the opinions of experts. Certain engineers maintain that with the aid of the protruding furnaces, which are becoming more and more commonly used, and which permit the use of broader sheets of water, improve the circulation of water about the furnace, and allow the use of braces which are longer, subjected to less lateral stress, and consequently less subject to breakage, it will be possible to prolong for many years the existence of the classical boiler of Stephenson. Other engineers assert that in view of the general employment of superheated steam, a maximum pressure of 12 atmospheres or 180 pounds will be amply sufficient, and that the evolution of the boiler can thus be retarded.—La Nature.

PHOTOGRAPHIC DEVELOPING.

AN ACCOUNT OF TWO MODERN METHODS.

For about a quarter of a century—that is, since the advent of the commercial dry plate made modern photography, and particularly amateur photography, possible—photographers have developed their plates according to an old established belief that the image obtained could be very largely controlled or modified, according to the development formula used. The results obtained gave apparent support to this belief, and it was, and in many quarters still is, followed to extreme lengths. Many developers have been put on the market, and recommended as giving some especially desired kind of negative, and the photographer's dark-room has gradually become a miniature laboratory.

It was not at first understood that the development of the image in a sensitive film is a chemical action, in which certain fixed factors will give uniform results. Now, however, it is gradually being grasped that this is so, and that the results obtained by the old-time "methods of control" are due to the practical experience of the worker who is by his selection of method merely eliminating or counteracting some error made at an earlier stage of his work. This has been amply demonstrated by the researches of Hurter and Driffield, Alfred Watkins, and others; and practical test has abundantly proved the correctness of their deductions. The researches themselves are too intricate to be described in brief space, nor are they necessary to the present article, but the practical results are simple and easily understood. The first conclusion gleaned from them is that success in negative making mainly depends on a correct exposure; and not on special skill or manipulation in development. This fact immensely simplifies photography, by putting the onus of success on exposure. And this is rendered the easier because the problem of exposure has for normal work been reduced to a matter of elementary arithmetic, the photographer, by the use of very simple calculation tables, being able to ascertain approximately the correct exposure needed for any special subject under varying conditions of light or of dry plate.

Alfred Watkins, the inventor of what is known as the "factorial" method of development, has been working along his own special lines for the last fourteen years, and has published some interesting conclusions. In regard to the many different developers, he points out that they vary widely in speed of working, and in time of the first appearance of the image, but that in other vital points, such as searching out of detail, fogging, or ultimate density power, there is no difference in their actions. His system is based on the relation between the two factors which vary in the different developers—the speed of working and the first appearance of the image. By experiment he has discovered that there is a relationship between the length of time required to show the first sign of image in a developing plate, and the time required to yield a fully developed negative. This factor varies widely as between different developers, but is constant for the same developer, whether the plate be under, correctly, or over exposed. The factor (except in the cases of pyro and amidol) depends on the developer and not on the special formula in which it is mixed. Diluting the developer, or adding alkali or bromide, may alter the time of first appearance but will not alter the factor (except in the case of pyro, where the quantity of bromide materially affects the factor; and

probably also in the short factor developers such as adurol or quinol). Temperature affects the speed of development but does not affect the factor.

Mr. Watkins publishes the following factors, which are arranged in their ascending order:

5	Adurol.	10	Ortol.
5	Quinol.	12	Diogen.
6	Imogen sulphite.	18	Amidol (2 grs. per oz.)
7	Glycin.	20	Edinol.
9	Eikonogen.	30	Metol.
10	Kachin.	40	Rodinal.
10	Pyrocatechin.	60	Diamidophenol.

PYRO-SODA OR PYRO-POTASH DEVELOPER.

Grains of pyro per oz.	Factor without bromide.	Grains bromide per oz.	Factor with bromide.
1	18	¼	9
2	12	½	5
3	10	¾	4½
4	8	1	4
5	6½	2	3

When the dry plate is placed in the developer, watch carefully for the first appearance of any image. This does not mean wait until the image is outlined in the film; but the moment when the highest light—probably the sky—appears. Carefully note the time, and multiply it by the factor number of the developer used; the result will give the time that the plate must be left in the developer to give a correctly developed negative. Thus if we are using eikonogen, with a factor number of 9, and the first trace of image appears in 40 seconds, the negative will be fully developed in 40 x 9 seconds, or 6 minutes. It would be possible, by forcing, to fully develop in a shorter time; or by diluting the developer the image could be retarded considerably; but in either case the factor would be the same, and nothing would be gained by the special manipulations. In the case of sky and cloud pictures, where there is nothing but sky; or in such subjects as architectural detail, where there is no sky or overpowering high light, the factor might be reduced one-third; in the supposed case of eikonogen given above the factor 4 being used. Portrait photographers may desire, not a "perfect" negative, but one that will give them some specially desired result. In these cases the factor number may readily be obtained by two or three experiments, and once obtained should be adhered to.

The insistent needs of the amateur photographer, with his great faculty of spoiling plates, and his persistent asking of questions, has led to the perfecting of a method which turns development, so far as he is concerned, into a blind mechanical action. Incidentally, the method has resulted in the partial abolition of the dark-room. The plates, or films, are placed in a tank in which they are developed, and while in the tank they are safe from light. In the case of a kodak film (for which a special tank is made) the whole operation, including the insertion of the spool, may be done by gas or lamp light; in the case of plates they must be placed in the tank in the dark, but once safely in the tank the latter may be brought into the light. By this method a number of plates or films—usually 12—are developed at once; a great saving of time and labor, as well as an increase in efficiency.

The tank method is the outcome of practical experiment, prompted by a business idea of saving the pho-

tographer from himself. If only the latter could be prevented from tinkering with his chemicals, and with his negative during development, his chances of obtaining uniformly good negatives would be increased. The value of uniformity in conditions is well illustrated by the question of temperature. The temperature most suited to development is 60 deg. to 65 deg. F. If the temperature rises to 80 deg. F.—and it may easily climb higher than that on a summer day—development will be completed in about half the time required with the solution at 65 deg., but the gelatine film may frill or melt, and be spoiled. If on the other hand the temperature falls 20 deg., development will be much prolonged. And either of these deviations from the normal will probably have a prejudicial effect on the quality of the negative.

To attain the required uniformity the makers of development tanks issue a formula which must be strictly adhered to in mixing the developer; they fix the necessary temperature at 65 deg. F., and they give a fixed time for the plates to remain in the tank. The only factor left in the hands of the photographer is exposure. Nowadays the photographer—even the beginner—may get fairly correct exposures. But whatever the exposure, practical trial has shown that the development tank gives the best all-round results from all kinds of exposures.

The tank itself is merely a jar, circular in the case of kodak films, or rectangular and grooved for plates; fitted with a light-tight cover. To insure uniformity the makers of tanks announce one special formula, to which they advise adherence. A good formula is sodium sulphite 60 grains, sodium carbonate 40 grains, pyro 20 grains, water 30 ounces. If a photographer wishes to use his own developer he may work out the formula by experiment. Develop a plate at a temperature of 65 deg. and note the time required. Simple arithmetic will show how much the developer should be diluted to take 20 minutes.

Tank development has proved such a practical saving, in time, chemicals, and percentage of results that the photo-supply houses who develop films for amateurs have very generally adopted the kodak tank method, in conjunction with a special kodak formula.

SANDS: THEIR RELATION TO MORTAR AND CONCRETE.

The whole subject of the testing of sands is open to investigation and will require careful experimenting and a number of tests before definite methods can be established. The chemical action and mineralogical composition of sand should also be carefully studied. That this influences the hardening of mortars is unquestioned, but there is no general agreement among writers on this subject. Mica is generally considered detrimental. Mr. W. N. Willis found that the addition of 2½ per cent of finely ground mica to Ottawa sand reduced the strength of the mortar at 28 days about 33 per cent and that the presence of flakes of mica greatly increased the percentage of voids. Clay matter, by which is to be understood hydrous silicate of alumina, and which must not be confounded with fine silicious earth, is often detrimental. Fine silicious particles unless present in large quantities are not detrimental and may be beneficial with lean mortars and coarse sands, as they tend to make a denser and more impermeable mortar. The exact action of the

mica and clay on the hardening of mortars has not been determined; the probabilities, however, are, that the action is entirely physical, as there is no known chemical reaction between the mica or clay and Portland cement during hydration. If the effect is other than physical it must be brought about by some obscure catalytic or electrolytic action which may either alter the speed of crystallization or the size and arrangement of the crystals or affect in some unknown way the colloidal action. Clay matter in order to be injurious must apparently be hydrous, as dehydrated clay in the shape of crushed bricks, etc., has been used successfully for concrete aggregate. The action of feldspar is not so well defined and it is probably not injurious unless partially decomposed. Crusher dust obtained from crushing hard feldspathic rocks, such as granite, has been successfully used as a substitute for quartz sand; yet as clay is formed largely from the weathering of feldspar its presence in natural sand to any large extent should always be regarded as a cause of suspicion. Decomposed, or partially decomposed organic matter, is also objectionable.

The nearer the sand approaches in its mineralogical composition to pure quartz the better will be the results obtained, other things such as size, granulometric composition, etc., being equal. It would, therefore, seem wise, until such time as full investigation has shown that the presence of other materials has no injurious effect, to confine ourselves to the use of as nearly pure quartz as can be commercially obtained.—Henry S. Spackman and Robert W. Lesley, in a paper read before the American Society for Testing Materials.

SINGING AND SPEAKING STONES.

SOME ANCIENT AND MODERN WONDERS.

BY PROF. GEORG ROSENFELD.

MAN'S love of the marvelous and mysterious has been gratified by the discovery, at various, places and epochs, of stones and sand from which issued sounds, apparently of supernatural origin. The phenomena exhibit so great a variety that the vocal stones may be separated into a number of distinct classes.

One of the most remarkable of these groups is exemplified by a sand bank about 60 feet high, on the southwest coast of the island of Hawaii. According to W. R. Trink a tone like that of a melodeon is produced by moving the hand in a circle through the loose sand. If the observer kneels, with both hands in the sand, and slides down the bank the sound becomes louder and louder until it resembles distant thunder and alarms horses tethered nearby. The loudest sound was produced when a native lay prone on the sand and another native dragged him by the heels down the bank, carrying a large quantity of sand down with him.

Dr. James Blake discovered by examining with a microscope thin sections of the grains of sand, which are of volcanic origin, that each grain was perforated by a narrow canal which, as a rule, was closed at one end. These peculiarly formed grains of sand appear to act as resonators, the air inclosed in them being set into vibration by the mutual friction of the grains. When the sand is damp the sound is not produced, because the friction is diminished and many of the tubular cavities are filled with water.

The singing sands of Mt. Sinai probably admit of a similar explanation. Wellsted describes the sand as yielding beneath the feet of a Bedouin climbing up the slope, not flowing down in a continuous stream, but breaking away in large masses. At first the sound resembled the faint tones of an Aeolian harp stirred by a gentle breeze, but as the motion became more rapid the sound was like that produced by a wet finger rubbed on the rim of a wine glass, and when the sand arrived at the foot of the mountain it made a noise like thunder, which shook the rock on which the traveler sat and so terrified the camels that it was difficult to hold them. This description is so similar to that of the singing sands of Hawaii that the presence of hollow grains of sand would account for the phenomenon of Sinai as well as for the other. But Schubert writes: "The Djebel Nakus or Bell Mountain, 400 feet high, is composed of sandstone bowlders loosely thrown together and covered with loose sand. When disturbed by the foot this sand falls into the interstices between the rocks, producing a sound that resembles a distant chime of bells and terminates in a roar." From this it appears that the falling of the sand between the bowlders is at least a contributory cause of the sound, and it may account for the whole phenomenon, even if the grains of sand are solid. According to Schubert, the Bedouins believe that the sounds come from the bells of a ruined Christian monastery.

Sounds of a very different character and origin are emitted by certain rocky cliffs in the Harz Mountains and in the Pyrenees. Two precipitous cliffs in the Harz, near Schierke, are called "The Snorers," from the peculiar sounds which the southwest wind draws from them. The faces of these cliffs are marked by deep gullies, which roughly resemble organ pipes open in front, and occasionally the front is practically closed by a stratum of air held motionless between the cliff and the trees which graze it, while the wind blows freely through the gullies, or organ pipes, behind. Similar phenomena, due probably to a similar cause, are observed on Mt. Maladetta, in the Pyrenees, where at sunrise certain cliffs emit plaintive sounds, which resemble those of a harp, and are known locally as "the matins of the damned."

Singing stones of a third category are found in various parts of the world. Fraas, journeying from the Red Sea to the Nile, saw a round, thin fragment an inch in diameter, resembling a shell, split off, with a peculiar sound, from a flint which lay baking in the hot sun at his feet. This observation is very remarkable and perhaps unique, for flints split gradually as a rule, but the violent and noisy rupture of the last bond under the influence of the sun's rays and in the presence of an observer does not seem impossible. Broken flints are common in the desert. Many persons have heard the noise caused by similar fractures of hard rocks and have seen the fragments roll down mountain slopes. Behm writes of the basalt columns of the Bamangwato hills, in South Africa: "In the evening, after a hot day, it was not unusual to hear the basalt crack and fall with a peculiar ringing sound, from which the natives inferred that the rock contained much iron." Here we undoubtedly find the most frequent cause of the singing of stones and the explanation of many of the observed cases. The phenomena are most conspicuous in hard rocks, which ring under the hammer, and especially in basalt and granite. They have been observed most frequently in Egypt. Jollois, Devilliers, and the younger Champollion often heard ringing, cracking sounds issuing from the huge granite blocks of the great temple at Karnak. Similar sounds have been heard in the temple at Philæ and in the granite quarries at Assuan.

Interesting in this connection is Humboldt's description of the musical stones of the Orinoco. These are granite cliffs, situated at the confluence of the Orinoco with the Rio Meta, which occasionally, according to various travelers, emit at sunrise sounds which resemble the tones of an organ. Humboldt, who did not hear the sounds, explained them as the result of the difference of temperature between the cool morning air and the air contained in the numerous very deep and narrow fissures of the rock, which still retained much of the heat absorbed from the sun's rays during the preceding day. Humboldt stated that he often found the surface of the rock, at night, 20 degrees F. warmer than the air outside, and he conjectured that "these organ tones which are heard when the ear is laid on the rock" were caused by the outrush of warm air through the narrow fissures which are partially obstructed by elastic laminæ of mica.

The French explorers in Egypt, on the other hand, attribute the sounds which they heard, not to air currents, but to sudden displacements occurring within the stone. Jollois and Devilliers assume that the superficial layer, heated quickly by the sun's rays, separates from the deeper and colder layers. Rozière speaks of the formation and extension of cracks between harder and softer minerals. Cordier assumes separation of quartz and other crystals from the surrounding magma, and finds an analogy in the sound emitted by ice exposed to sudden changes in temperature. Herschel compares the phenomena to the crackling of an iron grate when heated.

All of these conceptions and analogies are legitimate but it is very doubtful whether they are adequate, for we are not here dealing with sounds which are heard only "when the ear is laid on the rock." In Karanak and Philæ the sounds have attracted the attention of persons who were not listening for them. Cordier admits that many little cracks would be required to produce the sound. To me it appears more likely that a fragment of stone becomes detached and falls on a projection below. This supposition accounts for the ringing quality of the sound. Possibly, however, a similar sound might be produced by an internal fracture.

The story of a speaking stone of very different character has come down to us from ancient Egypt. This stone was one of the twin colossal statues of Memnon at Thebes. According to the myth, Memnon was the son of Eos, goddess of the dawn. He was turned to stone but still continued to greet his mother at sunrise. The statue, however, seems to have extended its greetings to earthly visitors of high rank. According to Balbilla, a literary lady attached to the court of Hadrian, the statue greeted the emperor three times, the empress twice, and a Roman general once, greeting the emperor at his first visit, but compelling the others to come a second time before it would condescend to speak. The voice of the statue is described as resembling the sound of a blow struck on bronze. The conscientious and trustworthy historian Strabo visited the statue, which was then partly destroyed, and writes that he heard a sound issuing from the vicinity of the remnant at sunrise, but that he could not positively state whether the sound came from the statue, its pedestal, or one of the attendants. Pausanias, on the other hand, expresses no doubt that the sound, which he compares to that of a lyre, came from the statue. The statue spoke only for those whom the gods loved and consequently vanity conspired with superstition to spread its fame. One way in which Memnon may have been caused to speak was suggested by my own experience. I visited the statue not at sunrise, but toward evening. A fellah asked if we wished to hear the "music." We assented, and he clambered up the colossus and vanished in a cranny at the elbow. At once we heard loud sounds of so metallic a character that I asked my donkey boy if the man was striking a bell. "No; a bar of iron," the boy replied. Yet I read in a recent guide book: "Even now the guide's hammer draws bell-like tones from the hard, resonant *stone*." If the guides can so deceive the makers of guide books, what wonder that Greek and Roman travelers were still more grossly deceived by the cunning Egyptian priests? As a matter of fact, the sound produced by striking the stone is not at all metallic.

My experience also suggests the reason why only one of the twin statues spoke, and why this one, though it retained its vocal powers after its upper part had been thrown to the ground by an earthquake in 27 B. C., became silent after its restoration by Septimius Severus about 200 A. D. The lower part of this statue may have possessed crannies like the one occupied by my musician, and these would naturally be filled in the process of restoration.—Condensed for the SCIENTIFIC AMERICAN SUPPLEMENT from Kosmos.

DRIFTING TO THE POLE.

KING HAAKON, of Norway, headed the list of subscriptions for Capt. Amundsen's next polar expedition with $5,000. No ship needs to be built, for Amundsen will have the "Fram," one of the greatest ice boats ever constructed, which took Nansen and Sverdrup north on two of the most fruitful of Arctic explorations. Norway is likely to raise all the money required, for his countrymen are very enthusiastic over Amundsen's brilliant scientific labors in the region of the north magnetic pole and his solution of the Northwest Passage problem by steaming through from the Atlantic to the Pacific. If he lives, he will start, as he proposes, in the spring of 1910, for Bering Strait, intending to put the "Fram" into the ice to the north of Point Barrow and drift wherever the ice may take him. He thinks the ice drift will carry him across the North Pole, but this is only an incident of his enterprise. If he can explore the unknown area around the pole it will be a feather in his cap, and he has good reason to believe that the ice drift will take him into that neighborhood or at least so near that he can reach it by sledge. All our present knowledge points to the probability that if he puts his vessel into the ice as far east as the longitude of Point Barrow he will be carried across the polar area to the other side of the world.

Three years after the "Jeannette" sank in the ice to the northeast of the New Siberia Islands some relics of the ill fated expedition were picked up on the southwest coast of Greenland. From all the available data Nansen, who is our leading authority on Arctic currents, and Prof. Mohn of Christiania, arrived at the conclusion that these relics could have reached west Greenland by no other way than across the pole. Between 1899 and 1901 about fifty drift casks were set

afloat in the ice north of Bering Strait, and one of them was picked up on the northeast coast of Iceland. Nearly five years and six months had elapsed from the day it was cast adrift north of Point Barrow, just where Amundsen expects to enter the ice, till it was found. From all that has been learned of the currents to the north of Asia by Nansen, Sverdrup and Cagni and of the east Greenland current which washes the shores of Iceland as it comes from the unknown North, the only conclusion reached is that this cask must have crossed the polar area in the neighborhood of the pole. There are flaws in every other hypothesis that caused them all to be set aside. Nansen has asserted for years that the way to reach the pole is by a drift voyage from the neighborhood of Point Barrow. He is one of the foremost promoters of the expedition which Amundsen is about to undertake. Nansen cares nothing for the mere attainment of the pole, but the physics of the unknown sea, the problems of its depth, tidal movements and currents, its chemical constituents, the life it supports, the contours of the sea floor, these and many other questions stir the enthusiasm of the man of science.

Amundsen and the men he will have with him are fitted for this work and will have plenty of time for their researches. There is little reason to believe that they will discover new land, but they will enter a rich field for oceanic investigations, and if their drift for years ends in the safe landing of their results there is little reason to doubt that they will throw light upon puzzling oceanic problems and enrich human knowledge as few other polar expeditions have ever done.

Amundsen will go out prepared to live seven years in the ice if it keeps him a prisoner that long. But he hopes to be back in four or five years.—N. Y. Sun.

MOVING WATER AND ANIMALS.

THE EFFECT OF AGITATED OR MOVING WATER.

BY DR. ARMAND BILLARD.

WATER is as necessary as air and light to the life of organisms, of which, indeed, it forms the chief constituent. One of the ways in which water modifies the process of evolution is illustrated by the morphogenetic action of running or agitated water upon animals—an apparently complex action which has hitherto eluded analysis. For convenience, the observed facts will be grouped under three heads, according as they relate to permanently fixed, temporarily fixed, or freely moving animals.

Fixed Animals.—The animals called Hydrozoa, which resemble plants in outward appearance, show the influence of water currents very distinctly. The family Campanulanda derives its name from the little bells or cups which surround the individual polyps of the composite plant-like animal and into which the polyps can retract themselves. In the species Obelia dichotoma, when growing in still water, every branch is terminated by a polyp and bell, but in straits swept by strong currents at high tide many branches bear no polyps and are greatly elongated. These long branches, which are called stolons, are very useful to the species, for at low water they sink down to the bottom of the shallow pool in which the creature has been left by the receding tide, attach themselves to pebbles by a viscous secretion which quickly hardens, and develop new plant-like colonies of polyps, in the manner of strawberry runners.

The effect of the current continues long after the cause has ceased to act, and colonies thus produced in turbulent waters continue to emit stolons after they have been transferred to the still water of an aquarium. The phenomena of regeneration, so easily brought about in these organisms, are equally dependent upon their original habitat. Cuttings from specimens growing in running water yield great numbers of stolons, but cuttings from specimens growing in still water usually develop a polyp at each end.
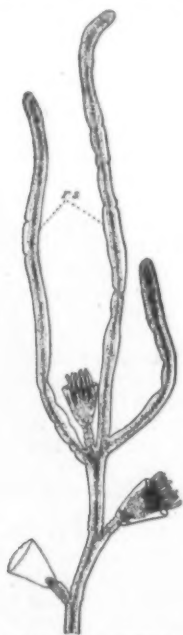

FIG. 1.—A BRANCH OF OBELIA DICHOTOMA, SHOWING POLYP BELLS AND STOLONS (rs).

Another species, Obelia longissima, is found in places where the depth of the water at low tide is sufficient to support the stolons which, instead of sinking to the ground, break off near their extremities as generative buds which are carried away by the current to found new colonies.

Examples of both of these methods of multiplication abound in the Hydrozoa. Stolonization also occurs and is similarly affected by currents in Bryozoa and Tunicates.

The formation of coral reefs and atolls may be explained by the effect of ocean currents in promoting the development of the coral-forming Actinozoa.
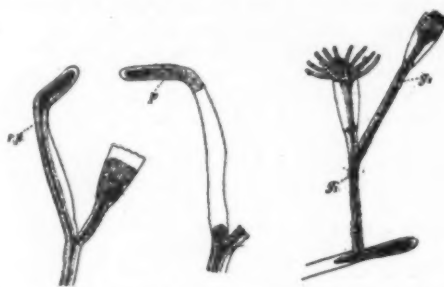
FIGS. 2 AND 3.—BRANCHES OF OBELIA LONGISSIMA, SHOWING GENERATIVE BUDS.
FIG. 4.—YOUNG COLONY OF OBELIA LONGISSIMA.

In certain cases currents contribute to the production of varieties. Giard has described four varieties of Circinalium concrescens, a composite Tunicate or Ascidian mollusk which forms large connected colonies in sheltered nooks, under rocks, but appears in the form of isolated individuals in waters subjected to continual agitation.

In other cases, again, the morphogenetic effect of currents is shown by the occurrence of forms that have been described as distinct species. These phenomena are common in Hydrozoa in which the effect of agitation of the water is to increase the size or the flexibility of certain parts of the colony.

Temporarily Fixed Animals.—In the marine Gasteropods known as limpets the conical shell is shallowest in animals attached to rocks on which the waves break most violently and in such situations the cone becomes a rude pyramid, a form which facilitates the flow of the water. In some species of fresh-water snails the foot is very large. These species are found in strong currents while species with smaller feet occur only in calm water.

The development of hooks and suckers may also be attributed to the long-continued action of water currents and waves. Such organs are found in some freely-moving animals. The remora bears on its head a sucker by which it attaches itself to other fishes and to vessels. Another fish, the Lepadogester, has a large sucker on its abdomen.

Suckers and hooks are especially abundant in parasitic animals, including internal parasites which are exposed to the action of moving liquids of the body. Striking examples are furnished in external parasites by the buccal and anal suckers of leeches and the hooked claws of the crustacean parasites which live between the gills of fishes where they are continually buffeted by the currents of respiration. The common tape worm (Taenia solium) is provided with both suckers and hooks, while a nearly related parasite (T. saginata) has suckers only.

Freely-Moving Animals.—The case of an animal moving through water is so similar to that of a fixed animal exposed to the action of currents that modifications of structure of the former may likewise be attributed to the morphogenetic action of water in motion. Such animals have acquired special organs, paired or median fins, which in their most primitive form are continuous longitudinal folds of the skin and in later stages of development become divided into several separate parts. The Amphioxus or lancelet, which is little removed from the parent type of the vertebrates, has one continuous median fin, and the paired fins of the torpedo appear in the embryo as two folds extending from head to tail.

The action of water is most strongly marked in fishes. With few exceptions, the body has the shape of a spindle or an elongated ovoid, with the broader end in front. There is no neck, but the head and body present a continuous curvature which offers minimum resistance to the water. The tail is powerful and has a motion similar to that of a screw propeller, and the fins maintain the equilibrium of the body. The torpedo-boat and the submarine with their elongated hulls, screw propellers, and lateral keels, closely imitate the model thus furnished by nature.

Certain animals, originally terrestrial, which have become adapted to an aquatic life, have acquired some of the characters of fishes. The wings of penguins and other diving birds have been transformed into fins. The seals and allied marine carnivora have had their limbs shortened and converted into swimming paddles which are almost, though not entirely, useless for locomotion on land. The hind limbs of cetacea (whales, porpoises, etc.), which adopted the aquatic life earlier than the seals, have entirely disappeared, and these animals are so helpless on land that they cannot regain the sea when storms have cast them up on the beach. The plesiosaurus, the ichthyosaurus, and some other reptiles of the secondary period show similar adaptations to aquatic life.

Such, in brief, is the evidence of the morphogenetic action of moving water. In some cases this action is direct, and even immediate (stolonization) but in general, although the mechanical action of water predominates, the ultimate result is partly due to other factors, such as the power of natural selection to give permanence to useful characters. It is necessary, also, to take account of the reaction peculiar to the particular organism called the ethological reaction and the inheritance of acquired characters. These two principles were formulated by Lamarck as follows:

"1. In every animal which has not completed its development, frequent and long-continued exercise of any organ increases the size and power of that organ, and continued disuse gradually weakens and degrades the organ and ultimately causes it to disappear.

FIG. 5.—A COMPOSITE GASTEROPOD, CIRCINALIUM CONCRESCENS, SHOWING A BUD IN PROCESS OF SEPARATION.

"2. Every character acquired by individuals in consequence of the influence of conditions to which the race has long been exposed, and hence of the use or disuse of particular organs, is transmitted to posterity, provided that this character has been acquired by individuals of both sexes, or by the parents of the new generation."—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Science au XXme Siècle.

WHITETHROATS.*

A STUDY OF A COMMON BIRD.

BY M. J. NICOLL.

THOUGH a very common English breeding bird, the whitethroat, or nettle-creeper as it is often called, is an unobtrusive little bird, and were it not for the curious actions with which it accompanies its song, it might often entirely escape observation. Suddenly shooting up from the middle of a thick bush or clump of brambles, as if thrown from a battledore, and leaping about in the air like a toy bird on a piece of elastic, all the while uttering its song, which is both varied and sweet, the whitethroat is to my mind one of the most interesting of our summer visitors. The common whitethroat, although it arrives in England during the second week in April, does not, as a rule, begin nesting until nearly the end of that month. The nest of this species is usually placed in a tuft of thick vegetation, nettles being often chosen for the purpose, whence the name nettle-creeper.

During the last summer I came across a whitethroat's nest, containing young, in a thick clump of grass at the foot of a hazel "tot," and as I was particularly desirous of obtaining photographs of this species, I visited the spot again the same afternoon armed with my camera and "rubbish-heap" hide. As I approached the nest I heard one of the birds utter a loud "Churr-churr!" of alarm, so I quickly withdrew until I saw them both leave the neighborhood of the nest in search of more food for their young. Hurrying to the nest and bending back the grass on each side, so as to let as much light in as possible, I crept into my hide, and by the time the parent birds were back with food had got my camera fixed and focused upon the nest. My hide was made from the directions given by Mr. R. Kearton in his most useful book, "Wild Life at Home." I have, however, painted the cover of mine with Condy's fluid, which causes it to be less conspicuous than if it was covered with plain brown holland, and, at the same time, it is, I find, not necessary to completely cover it with wisps of dry grass when it is thus painted. I had great success with this form of hide during last summer, even with shy birds such as skylarks; but I find that the great secret is to fix up the "rubbish-heap" while the birds which one is desirous of portraying are away getting food; otherwise, if they see one enter they are often very shy of approaching the nest for some time. But to return to our whitethroats. I did not expect to have long to wait for my photographs, nor was I disappointed, for in less than forty-five minutes I had exposed six plates successfully. Both the male and the female took part in feeding the young, and from where I was concealed I could always tell when they were coming with food, as they signaled their arrival at a patch of undergrowth near the nest by uttering a soft "churr," and a few seconds later I could hear one of them creeping up to the nest through the grass. They always made their appearance on the far side of the nest from where I was concealed. Sometimes the birds had a large green caterpillar in their bills, but more often they seemed to bring some insect food from the back of their throats, with which they fed their young, and the quantity was often enough to feed two of the youngsters. The male whitethroat may be at once distinguished from its mate by its

FEMALE COVERING YOUNG DURING SHOWER.

grayish head and its pink tinged breast. I noticed that both birds paid about an equal number of visits to the nest, and in one photograph the female is to be seen in the act of putting food into the young bird's mouth. At the end of each visit the birds attended to the sanitary arrangements of the nest, often turning the young over with their heads so as to make sure that the nest was clean. Almost directly after I

* Country Life (London).

had exposed my last plate the female settled down on the nest and covered the young from the sun, which was very hot, and while doing so kept up a continuous panting, evidently from the heat, which I began to feel almost tropical inside my "rubbish heap." As I

HEN WHITETHROAT FEEDING YOUNG

had no more unexposed plates with me, I determined to visit the nest the next day and try to picture the female bird in this position, but although I succeeded in getting a wonderful photograph, the weather had totally changed, and instead of panting with the heat she was shivering with the cold; but more of this anon. As I was now ready to leave the nest, the question was how to get the bird off the nest without showing myself, which might have been fatal to my prospects the next day.

I tried whistling, without success, then coughing, then shouting; but still she remained unmoved. As a last resource I seized hold of the front of my "rubbish heap" and shook it violently, all the while coughing and hissing, and after a while this had the desired effect, for she slowly rose up and hopped sedately, if a bird can hop sedately, off the nest and disappeared into the undergrowth. Then I crawled out of my hide into the fresh air, and, packing up my apparatus, went home, and straight into the dark room.

The next afternoon I went to the nest again, but, alas, for our treacherous climate, as soon as I had got my camera fixed in position, and myself concealed comfortably in my hide, the sun went in, and in a few minutes a regular downpour of rain came on. Although rain was much wanted for the crops, I did not desire it for that afternoon. However, it was going to do me a good turn, for while I sat under my "rubbish heap," with the rain beating down on it, the female whitethroat returned to the nest, fed the young, and then, settling down, covered her offspring from the shower with her wings and body, and while in this position, with the raindrops glistening on her, I made a series of photographic studies, one of which forms the first of my illustrations. I was forced to spend some three hours in my hide on this occasion owing to the rain, and during nearly all this time the female sat on the nest, and only twice were the young ones fed. The male paid one visit to the nest with a big green caterpillar. The female slipped off while he fed the now ravenous chicks, and then covered them again. When the sun came out, the female flew off for food, and I packed my "rubbish heap," and turned homeward, pleased with my success at photographing a wild bird protecting her young from rain.

"Filling Up."—This carriage surfacer or filler, originating in England and used in wagon factories. It is gray to brown and is applied with a spatula. It is prepared by grinding in a paint mill, 16 parts of white lead, 15 parts of dark brown umber, 20 parts of chalk,

30 parts of heavy spar, 12 parts of siccative, 5 parts oil of turpentine, and 20 parts of linseed oil varnish.

DISINFECTANTS.

THE recently deceased Russian privy councilor, Prof. Modest Kitary, produced a series of disinfectants, which, on account of their excellent efficiency and low cost of production, deserve to be well known. The disinfectants are (a) aromatic or cabinet powder, (b) ordinary powder, (c) powder for horse stables, (d) aromatic-carbolic fluid, (e) rosin-carbolic fluid.

a. *Aromatic or Cabinet Powder* consists of 12 parts of fine brick dust, 6 parts of slaked lime, 1.375 parts of calcined soda, 0.315 part of tar, 0.150 part of essence of mirbane, 0.150 part of acetic ether, 0.1 part of crystallized carbolic acid. First the fluid and aromatic constituents are mixed together, as follows: The tar is poured into a sufficiently large glass, with the mirbane essence and the acetic acid, and allowed to stand, closely covered, for a day, being vigorously shaken a few times, so that everything is dissolved and the turbid fluid gradually clears. The dry materials, such as the brick dust, slaked lime, and, soda, are put into a box, well mixed up and the fluid poured into them. After the latter has been completely absorbed by the powder, it can be packed in suitable receptacles (glasses or canisters).

b. *Ordinary Powder.*—10 parts of brick dust, 8 parts of slaked lime, 1½ parts of calcined soda, ½ part of tar, 0.120 part of crude carbolic acid.
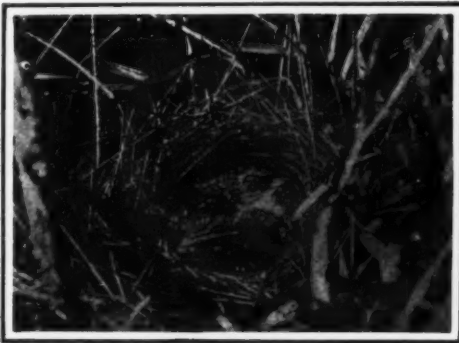
c. *Powder for Stables.*—80 parts of brick dust, 100 parts of slaked lime, 15 parts of calcined soda, 10 parts of tar, 5 parts of crude carbolic acid. The preparation of this powder is effected in the same manner as described for a.

d. *Aromatic Carbolic Fluid.*—The preparation of this fluid is somewhat more complicated, demands accuracy, cleanliness of the vessels used, and purity of materials. It is composed of 92 parts extract of musk, 17.5 parts acid, carbolic. pur. phosph., 82 parts oil of wintergreen, 109.4 parts of acetic ether, 5,500 parts of rectified spirits, 10,465 parts of distilled water. The process of preparation is divided into three operations: 1, the preparation of the aromatic mixture; 2, mixture of this with alcohol, and 3, stirring the whole into water. In preparing the acid. carbolic. pur. phosph., put the carbolic acid in a suitable glass and heat it to 100 deg. to 122 deg. F. As soon as the carbolic acid has become liquid, a small piece of phosphorus is added to it and this is allowed to stand in a warm place for 24. hours, being frequently stirred, so that the phosphorus can dissolve. The latter imparts to the fluid the property of rapidly purifying the atmosphere, without impairing the hygienic properties of the carbolic acid. The musk must not be used in its natural state, but must be purified with acetic ether. Pour into a glass 5,653 parts of acetic ether and add to it 2.2 parts of musk, so that the latter is extracted. The yellow fluid is filtered off from the residue, and fresh ether added to the residue, until

WHITETHROAT GOING ON TO NEST.

the musk is thoroughly extracted; the oil of wintergreen must be colorless and in no case yellowish, as the latter color is indicative of oxidization and only such as is not oxidized is capable of ozonizing the air. In its preparation, pour 17.5 parts of acid. carbolic. pur. phosph. and 113 parts of wintergreen into a flask, shake and add 110 parts of acetic ether and 92 parts of musk extract. This mixture is now slowly poured, being constantly stirred, into a suitable ves-

sel containing 5,267.5 parts of rectified alcohol. If the resulting fluid is not perfectly clear, it must be filtered through cotton wool. Into the same vessel, now, pour, without interruption, the 10.465 parts of water, and after the addition is complete, begin to stir. If the fluid is not absolutely clear, but milkily turbid, add alcohol to it, until it is again perfectly clear.

e. *Rosin-carbolic Fluid.*—2,250 parts of caustic soda, 4,500 parts of tar, 2,250 parts of acid. carbolic. flav., 41,000 parts of water. Take 20,500 parts of water, boil it, then add the caustic soda so that it is completely dissolved, then add the tar and carbolic acid. The hot fluid must be stirred until all is dissolved, and then add 20,500 parts of water to it.

AN ANIMAL AS AN ENGINEERING STRUCTURE.

SOME FACTORS OF SAFETY PROVIDED BY NATURE.

BY PROF. S. J. MELTZER.

FOLLOWING the old divisions of the organs of animal life in reproductive, vegetative, and animal systems, we may say, perhaps, that the reproductive system is provided most and the animal system is provided least with factors of safety, while in the vegetative system, which in that regard occupies a middle position, those organs which seem to be less well differentiated, like the organs for internal secretion, seem to be provided with a larger surplus of tissue.

The complex apparatus of circulation is well provided with factors of safety. In the first place, the animal body possesses a good deal more blood than it requires for its work. It is known by experimental evidence and clinical observations that nearly one-half of the blood can be withdrawn without serious consequences to the life of the animal. As a further factor of safety in this regard we might register the ability of the blood to recover its loss very rapidly.

Furthermore, the capacity of the entire system of blood vessels in a complete relaxed state is again much greater than the volume of blood of the body. It is this difference between the volume of blood and the volume of the vessels which greatly facilitates the circulation of the blood and the proper nutrition of the various organs of the body. On the basis of this difference large quantities of blood can be thrown at once and with ease into the splanchnic region, into the skin or into the working muscles. After a local injury or infection in a very brief time for the sake of repair or defense hyperæmia sets in, and vessels which were not noticeable before become fairly visible. An instance of a similar order is the wide-spread institution of collateral circulation. Around an anemic focus blood vessels which previously were hardly visible become full and large to meet the threatening danger of necrosis of the neighboring anemic tissues. All these devices which spring into activity only under special exigencies, are manifestly factors of safety and are made possible by a superabundance of blood vessels.

The difference between blood volume and capacity of vessels is an indispensable factor of the circulation, and its permanence is assured by many devices. Thus, for instance, any artificial increase of the volume of blood is immediately corrected through the chief eliminating organs, or through the secretory glands, or even by throwing some of the surplus serous fluid temporarily into the lymph spaces and serous cavities. Œdema, ascites, and hydrothorax are sometimes not parts of the affliction, but means of repair.

Furthermore, existence of the difference between vascular capacity and quantity of blood is made possible only by a wonderful mechanism which controls in every part of the body the mutual adaptation of blood and vessel—the so-called vasomotor apparatus. It causes the dilatation of the vessels in the part of the body which requires and is to receive more blood, at the same time causing a constriction of the vessels in a part which can spare some of its blood. This mechanism is so important that it is again guarded by an abundance of factors to assure its safety. There is a vasomotor center in the medulla oblongata; when this is destroyed, a number of vasomotor centers in the dorsal medulla assume control; when they are eliminated, the sympathetic ganglia take over the command, and when they too drop out, the vascular wall itself attends to the proper regulation and adaptation of the capacity of the vessels to the volume of blood.

Finally, the chief motor mechanism of the circulation, the heart, is a clear instance of an organ provided with a superabundance of volume and force. Normally it is in a state of tonus and receives only a moderate volume of blood which it throws into the aorta with no great hurry and with an expenditure of only a moderate amount of energy. But at any moment it is ready to receive many times the usual volume of blood, is ready to double or treble the rate of its beats and is capable of developing nearly any amount of energy which the situation might require.

We have, then, in the circulatory system many instances of provisions with factors of safety to assure

* Harvey Society lecture, delivered at the New York Academy of Medicine.

nutrition of all parts of the body in all states and conditions. An abundance of blood, a superabundance of blood vessels, a vast provision of factors for the safety of the adaptation of the two to one another and a great reserve of motor force for transportation and distribution of the blood.

The multiple mechanisms existing for the care of the vasomotor apparatus lead us to the following considerations: The internal motor organs of the body, like the gastro-intestinal canal, the heart, the uterus, etc., are provided with central motor innervations as well as with local motor mechanisms. In all cases it has been shown that the movements of the organs continue also after the severance of the connections with the central nervous system. Thus the heart continues beating after section of both vagus and accelerator nerves, the peristalsis of stomach and intestines continues after cutting the vagi and the splanchnics, and pregnancy and delivery take a normal course after complete destruction of the spinal cord. On the basis of these facts it is now generally assumed that the extrinsic innervations of these organs have only a regulating function, while the real motor function is invested in peripheral devices, be they of neurogenic or of myogenic character. This conclusion is obviously based on the supposition that the function of an organ is carried on only by a single mechanism. Hence the fact that the motor work is carried on after eliminating the extrinsic nerves seems to be sufficient evidence that they cannot form an integral part of the motor function.

These conclusions are fallacious. There is an abundance of instances in which one and the same function is cared for by more than one mechanism. But we need only refer to the vasomotor apparatus. It was known before and it has been very recently conclusively demonstrated again by Magnus that, after eliminating the influences of the sympathetic and the central nervous system, the blood pressure is well taken care of by the peripheral mechanism of the walls of the blood vessels. Nevertheless, nobody doubts that the vasomotor centers are integral parts of the vasomotor mechanism. Why this difference of views for the different organs of the body?

The subject is evidently an important one; but we shall not enter into a further discussion of it. The remarks were made to illustrate the importance of the conception that in the animal body one function is not infrequently cared for by more than one mechanism. It is capable of profoundly affecting the views on many vital biological problems.

We shall cite a few more instances in which two or more parallel mechanisms exist for the accomplishment of one function. I may be permitted to mention in the first place the function of deglutition. As was shown by us about twenty-five years ago, fluids and semifluids are squirted down from the mouth to the cardia by the force of the contraction of the mylohyoid muscles, but they can also be carried down by the peristalsis of the œsophagus. Of the latter there are again, as I have recently shown, two kinds: a primary peristalsis which runs independently of the integrity of the œsophagus, and a secondary peristalsis which is closely connected with the integrity of the tube and which is more resistant to certain detrimental influences. It will probably be shown before long that the œsophageal wall alone is also capable of contributing to the function of carrying the food down to the stomach.

The function of the pancreatic secretion seems to be an instance in which mechanisms of a different type are sharing in its management. It has long been established that the pancreatic secretion stands under the influence of the central nervous system. Recently it was discovered by Bayliss and Starling that an intravenous injection of secretin causes a considerable increase of pancreatic secretion. Secretin is an extract made of the duodenal mucosa with an addition of hydrochloric acid. It is assumed that this substance is produced normally when the acid chyme comes in contact with the mucosa of the duodenum, and that by its absorption into the circulation it is one of the normal causes of pancreatic secretion. Now the effect

of the secretin seems to have nothing to do with the nervous system, since the injection is active even after all connections with the nervous system are destroyed. On the other hand, in cases of achylia gastrica, in which the stomach is devoid of all secretion, the pancreatic secretion is apparently normal, as the digestion of proteids remains undisturbed. But since in these cases there is no secretion of hydrochloric acid secretin ought to be absent; here the pancreatic secretion is probably attended to properly by the other partner in the management of the function, that is, by the central nervous system.

A double management of partners of a different type exists probably also for the mammary secretion. There is sufficient evidence that the secretion of milk is under the influence of the nervous system. Nevertheless, the secretion continues after all nerves going to the mammary glands are cut. The milk secretion in the latter case is probably kept up by a stimulation through an internal secretion provided by the reproductive organs. Internal secretion is probably a co-existing factor in many functions of the body.

Furthermore, there are instances in which one function is cared for by two separate organs. The function of digestion of proteids in the alimentary canal is carried on by two separate organs with a different chemical activity: the pancreas and the stomach. The trypsin of the pancreas digests proteids in an alkaline medium, while the pepsin of the stomach is active only in an acid medium.

An arrangement of a similar character we meet with in the organization of the function of the defense of the body carried on by the white cells against foreign invaders. This cellular army of defense is made up of two types: the microphages, the polynuclear leucocytes whose abode is in the bone marrow; and the macrophages, the large mononuclear cells which have their barracks in the lymph nodes and lymphoid tissue. According to Opie one of the effectual weapons of these warriors is their intracellular proteolytic ferments. But the ferment of the microphage is active in an alkaline medium, while that of the macrophage requires for its activity an acid medium.

As factors of safety we may consider also the assistance which one organ lends to another or the vicariation of one organ for another. For instance, the assistance which the sweat glands render to the kidney in the process of elimination of a surplus of water, or the vicariation of the mucous membrane of the intestinal canal in the process of elimination of urea. Such mutual assistance of the organs is a widespread institution in the animal body and assures the safety of many vital functions.

Returning to the organs which are provided with a large surplus of active tissue, the question confronts us: which is the mode of distribution of the normal activity of an organ among its luxurious tissues? Since the activity of such organs, as we have seen, is far below the capacity of their tissues, the distribution could occur only in two ways. Either some parts of the tissues work to their full capacity, while the other parts remain idle, being only in readiness for emergencies—like the unemployed vice-president of some organization—or all elements of the organ take equal part in the work, each tissue element employing only a fraction of its capacity for work. The last alternative is probably the more frequent mode of distribution. There are, for instance, probably no totally inactive glomeruli and tubules in the kidneys, no inactive liver cells, no thyroid epithelial cells entirely without colloidal substance, but the epithelium of the glomeruli and tubules work only one-half of their capacity, the islands of Langerhans work less than one-tenth, the vesicles of the thyroid about one-sixth of their capacity, etc. For the muscles of the heart it is generally assumed that all the fibers take part in every contraction, but that they work normally only a fraction of their capacity. On the other hand, there are organs in which surely parts of the tissue do not take active share in the work, unless called upon under special circumstances. In the ovaries, for instance, surely only one ovum becomes fertilized,

while all the others are only on the waiting list. An instructive instance is the mode of distribution of work among the respiratory muscles. In normal inspirations, for instance, we find only the diaphragm alone at work. When somewhat deeper breathing is required, the inspirations are supported by the levatores costarum and the scaleni. Furthermore, in labored respirations also the sternohyoid and the posterior superior serrati become engaged in the work, and when the difficulties become still greater, still other groups of muscles enter into the struggle. In other words, the different groups of muscles which are designated to do the work of inspiration are not engaged in it in the manner of partners of equal standing, but enter upon their duties as a series of vice-presidents or rather as a series of reserve forces. On the other hand, in the diaphragm probably all the muscle fibers are engaged in the work of each inspiration at all times, employing only a fraction of their capacity in normal or shallow inspiration and working to their utmost capacity in dyspnœa or asphyxia. We see, therefore, in one and the same function both modes of distribution of work well represented, one muscle steadily at work with all fibers, like a heart, adapting the degrees of their energies to the various requirements of their work, and a number of groups of other muscles, acting as graded reserve forces, idle but ready for emergencies—instructive examples of luxurious factors of safety.

In the foregoing we have brought forward a sufficient number of instances in which various parts of the living organism are provided with a superabundance of material and energy to warrant the comparison of the organism with a machine with regard to the provision with factors of safety.

One of the fundamental differences between living organisms and human-made machines is that the former carries in it the germ for self-propagation, while machines have to be made by human hands. As a further difference between the two constructions we may perhaps consider the phenomenon of self-repair. Possibly the phenomenon of self-repair in the organism is closely allied with the phenomenon of self-propagation. The same source which provides the organism with a mechanism for a reproduction of the entire body provides its parts with a mechanism for regeneration of these parts. Reproduction and regeneration might have a common cause. At any rate, self-repair distinguishes the organism from the machine. If parts of a machine yield to stress and the factors of safety become exhausted, the machine would surely break down, unless it is repaired by human hands, just as it is made by human hands. As far as I know, no machine has yet been invented which is provided with devices for a continual self-repair. In the living organism self-repair is a widespread function of living tissues and organs. It is a dormant force, a reserve force, which springs into immediate activity as soon as any injury is inflicted. It is a factor of safety peculiar to the living organism. It manifests itself in the forms of regeneration and hypertrophy of tissues and organs, and also in the functional forms of inflammatory reaction, of substitution, vicariation, and adaptation. And here it is interesting to observe that self-repair does not set in only when the margin of safety is exhausted, when there is an actual need for repair, but already when only the integrity of the factors of safety is encroached upon. Self-repair is a factor of safety also for the protection of the factors of safety. When, for instance, one kidney is removed, the hypertrophy of the secreting elements begins a few hours later, although the urinary secretion was hardly impaired. It is an attempt to reprovide with luxurious tissue. The liver cells regenerate, the thyroid, the adrenals, and other organs hypertrophy and regenerate even when the preceding injury was not extensive enough to affect the function of these organs. It is, as stated before, an attempt to restore the factors of safety. A heart working above normal becomes hypertrophied even if it has not yet met with any obstacles; it is a provision in time against possible shortcomings; it is a repair of the factors of safety. This is a very interesting field, but it would lead us too far to enter upon a detailed discussion of the various aspects of the subject. We would only call attention to two exceptions. One is the very scanty repair which takes place in the organs of reproduction. But the affluence is here so immense that the organs may safely forego the benefits of self-repair. The other exception concerns the nerve ganglia; nerve cells as a whole do not regenerate. We have learned above that the ganglionic masses of the central nervous system are scantily provided with factors of safety. Here we learn that they are also deprived of the great aid afforded by regeneration. There is some functional self-repair in the central nervous system. Other centers assume the work of the lost ones; adjacent tissues become educated to the work; dormant centers of the opposite hemispheres wake gradually up to their new missions. But all these substitutes are insufficient satisfactorily to replace the lost function, not to speak of a provision for factors of safety.

Here we must recall that the lack of regeneration applies only to the nerve cells. The nerve fibers, on the other hand, especially those of the peripheral nerves, show rather a very active regeneration.

The foregoing review shows, I believe, conclusively, that the tissues and organs of the living animal organism are abundantly provided with factors of safety. The active tissues of most of the organs exceed greatly what is needed for the normal function of these organs. In some organs the surplus amounts to five, ten, or even fifteen times the quantity representing the actual requirement. In the organs of reproduction the superabundance and waste of tissue for the sake of assuring the success of the function is marvelous. Furthermore, the potential energies with which some organs, like the heart, diaphragm, etc., are endowed, are very abundant, and exceed by far the needs for the activities of normal life. The mechanisms of many functions are doubled and trebled to insure the prompt working of the function. In many cases the function of one organ is assured by the ready assistance offered by other organs. The continuance of the factors of safety is again protected by the mechanisms of self-repair peculiar to the living organism. We may then safely state that the structural provisions of the living organism are not built on the principle of economy. On the contrary, the superabundance of tissues and mechanisms indicates clearly that safety is the goal of the animal organism. We may safely state that the living animal organism is provided in its structures with factors of safety at least as abundantly as any human-made machine.

The safety of a mechanism is increased, as we have stated before, also by an economic handling of the expenditure of its energy. The expenditure of energy by the living animal organism consists chiefly in the work which it performs, that is the contractions of the muscles. Of the involuntary work of the body it is only the action of the heart and the respiratory muscles of which we possess a knowledge of some available facts. The heart, although capable of doing a great amount of work, is normally kept down to perform only the most indispensable duty. The inhibitory tonus exercised by the vagi prevents the heart from beating too rapidly and too strongly, when it is not required; and the vascular reflexes carried from the heart or aorta to the vasomotor centers regulate the vascular circulation so as not to offer too much resistance on the one hand, and not to fill up the heart with too much blood on the other hand.

The respiration is normally carried out only by one muscle, the diaphragm, and this works only with a fraction of its capacity, the distention of the lungs producing an inhibitory stimulus preventing the muscle from overaction.

The contractions of the skeletal muscles being regulated chiefly by the will, offer insufficient opportunities for a study of the normal regulation of expenditure of energy emanating from this source. There are, however, two facts which are instructive and deserve to be mentioned. One is the provision of the muscle with the sense of fatigue setting in with overexertion; it might serve as a guard against overwork, against exhaustion of the muscles. The second fact is the provision of the muscular innervation with inhibitory impulses for antagonistic muscles; it prevents harmful or even only unnecessary contractions. In other words, it prevents the muscles from an unnecessary expenditure of energy.

While the facts are not many, they are sufficient to indicate the tendency of the organism to be economical in its expenditure of energy.

We now arrive at the examination of the principles of governing the supply of the organism with energy. A machine is provided with fuel far above the necessity for the performance of the expected minimum work; it has to be in readiness for unforeseen exigencies. How about the organism? The supplies for the animal machine consist of inorganic salts, water, oxygen, and food. Our knowledge of the laws governing the supply and expenditure of water and inorganic salts for the animal organism are still too imperfect to be utilized here for the elucidation of our problem. We have to restrict our discussion to the supply of food and oxygen. The supply of food is influenced so much by the will of the animal that it is difficult to obtain facts permitting only one interpretation. For instance, the amounts of food taken by men in all parts of the world can not be taken as the normal quantity which the body requires, because, as Chittenden and his school say, this amount is dictated by habit and not by actual necessity. The latter found, as stated before, that with a proteid diet lower than the one employed in the current diet of man, a number of men continued their normal life without special incidents. As a result of this observation these investigators assume that the minimum proteid diet is the normal one and advocate its adoption as a standard diet. The finding that men can continue to live with a certain minimum is a fact; the assumption that this minimum is the actual requirement of the organism, is, however, only a theory, and a theory which decides that in contrast to a human-made ma-

chine the animal machine should be provided with a minimum supply of energy just sufficient for the average daily incidents and daily work.

Neither can we, on the other hand, look upon the facts which were brought together in this lecture as an absolute proof that the animal's supply of energy ought also to be provided on the same plan of superabundance. It may be claimed that the animal's welfare is best cared for by observing stringent economy in the supply of its energy.

Luckily, however, the supply of oxygen to the organism is a process practically entirely independent of the will, and therefore a fact or two which we find here may well throw some light upon our problem.

One fact here is indeed instructive. It is a frequently made and well established observation that the oxygen of the inspired air may be reduced to about one-half of its normal amount without causing any ill effects whatsoever. The oxygen of the atmospheric air amounts to about 21 per cent, and it may safely be reduced to about 11 per cent or 10 per cent. Nature then supplies oxygen to the animal body in an abundance amounting to at least to twice the maximum quantity which the normal condition of life may require.

Furthermore, even with an atmosphere greatly reduced in oxygen the body is capable of attending to work so strenuous that it may cause a consumption of oxygen perhaps five times the amount normally used up during rest or light work. This occurs, as was demonstrated in the interesting experiments of Zuntz and his co-laborers, in climbing mountains and carrying at the same time considerable loads at altitudes with a barometric pressure of less than 500 millimeters of mercury.

We should also remember another instructive and characteristic fact, namely, that the venous blood is comparatively rich in oxygen, possessing often nearly two-thirds of that present in the arterial blood, which means that the oxygen carried in the arterial and capillary blood is greatly in excess of the requirements of the cellular tissues.

Finally, another interesting point is that labored breathing sets in long before the tissues are in actual need of oxygen. Dyspnœic breathing is a device to cause a refilling of the exhausted surplus of oxygen by a more efficient pulmonary ventilation. The hard-working skeletal muscles which consume an undue amount of oxygen produce at the same time a substance which stimulates the respiratory center to greater activity and thus to a more liberal provision of oxygen. This is again a sort of self-repair of the loss to the factors of safety.

All this is sufficient evidence that as far as oxygen is concerned the supply of the body with energy is certainly not conducted on the principle of stringent economy. On the contrary, abundance is the guiding rule here, as it is in the provisions of the body's structures.

We now again return to the question of supply of food. The presence of an abundant supply of glycogen and fat in all animal bodies seems to me to be a sufficient indication that carbohydrates and fats are not supplied on the principle of stringent economy. Fuel material is here abundantly stored up not so much for its immediate use but essentially for use in unforeseen exigencies. As far as I know the claim has not yet been raised that these savings deposits are due only to acquired habits of ingesting too much of the mentioned forms of food.

With regard to the proteid diet, however, the question of the normal supply, as we have repeatedly mentioned, is not above discussion. In a recent review of the subject by Benedict one of his precise statements reads: "Dietary studies all over the world show that in communities where productive power, enterprise and civilization are at their highest, man has instinctively and independently selected liberal rather than small quantities of protein." Chittenden, on the other hand, says: "All our (experimental) observations agree in showing that it is quite possible to reduce with safety the extent of proteid catabolism to one-third or one-half that generally considered essential to life and health." And then adds: "It is obvious . . . that the smallest amount of food that will serve to maintain bodily and mental vigor . . . is the ideal." As valuable as the facts which Chittenden and his co-laborer found may be, they do not make obvious their theory that the minimum supply is the optimum—the ideal. The bodily health and vigor which people with one kidney still enjoy does not make the possession of only one kidney an ideal condition. The finding that the accepted standard of proteid diet can be reduced to one-half can be compared with the finding that the inspired oxygen can be reduced to one-half without affecting the health and comfort of the individual. But nobody deduces from the latter fact that the breathing of air so rarefied would be the ideal. Chittenden suggests that a greater use of proteid might be the cause of many ills, for instance of gout and even of tuberculosis and cancer. I shall not attempt to discuss the merits of this theory as far as the causation of tuberculosis and

cancer is concerned. As to the causation of gout, one of Chittenden's most able supporters, Otto Folin, has pointed out that at best this could be claimed only for eating crude meat but not for an ingestion of protein in general, because the latter becomes converted into harmless urea, as Folin says. I would add that if we should avoid eating meat because some of us might sometimes get gout, we should surely avoid eating carbohydrates because it sometimes leads to diabetes, and avoid eating fats because it often leads to various mischiefs. What then shall we eat with absolute impunity?

But I wish to recall here one fact, namely, that the administration of too large a dose of thyroid extract leads to a pathological condition similar in character to that of Graves's disease. The normal body nevertheless possesses, as we have shown above, a great surplus of thyroid tissue without causing any thyroidism. That some isolated metabolic product might do some harm when artificially incorporated into an animal is far from being fair evidence that this normal product of the animal mechanism does harm there when in its normal connections. Metabolic products are present in great abundance in all healthy individuals without causing mischief.

The situation seems to me to be this: All organs of the body are built on the plan of superabundance of structures and energy. Of the supplies of energy to the animal we see that oxygen is luxuriously supplied. The supply of carbohydrates and fats is apparently large enough even to keep up a steady luxurious surplus. For the supply of proteid we find in the actual conditions of life that man and beast, if they can afford, provide themselves with quantities which physiological chemists call liberal. This may or may not be the quantity which nature requires and approves of. Experiments have shown that a number of men subsisted on the half of such quantities. This latter might be an indispensable minimum, just as there is an indispensable minimum for all other luxuriously endowed provisions of the animal organism, and the liberal ingestion of proteid might be another instance of the principle of abundance ruling the structures and energies of the animal body. There is, however, a theory that in just this single instance the minimum is meant by nature to be also the optimum. But it is a theory for the support of which there is not a single fact. On the contrary, some facts seem to indicate that nature meant differently. Such facts are, for instance, the abundance of proteolytic enzymes in the digestive canal and the great capacity of the canal for absorption of proteids. Such luxurious provision for digestion and absorption of proteids is fair evidence that nature expects the organism to make liberal use of them. Then there is a fact that proteid material is stored away for use in emergencies, just as carbohydrates and fats are stored away. In starvation nitrogenous products continue to be eliminated in the urine which, according to Folin, are derived from exogenous sources, that is from ingested proteid and not from broken-down organic tissues. An interesting example of storing away of proteid for future use is seen in the muscles of the salmon before they leave the sea for the river to spawn. According to Miescher the muscles are then large and the reproductive organs are small. In the river where the animals have to starve the reproductive organs become large while the muscles waste away. Here in time of affluence the muscles store up nutritive material for the purpose of maintaining the life of the animal during starvation and of assisting in the function of reproduction. This instance seems to me to be quite a good illustration of the role which the factor of safety plays also in the function of the supply of the body with proteid food. The storing away of proteid, like the storing away of glycogen and fat, for use in expected and unexpected exceptional conditions is exactly like the superabundance of tissue in an organ of an animal, or like an extra beam in the support of a building or a bridge—a factor of safety.

I therefore believe that with regard to the function of supply of tissue and energy by means of proteid food nature must be governed by the same principle of affluence which governs the entire construction of the animal for the safety of its life and the perpetuation of its species.

Before concluding I wish to add the following remark: It seems to me that the factors of safety have an important place in the process of natural selection. Those species which are provided with an abundance of useful structure and energy and are prepared to meet many emergencies are best fitted to survive in the struggle for existence.

Farrant's liquor, for the preservation of vegetable organisms, consists of 35 parts of distilled water, in which, while boiling, 0.1 part of white arsenic is dissolved. The cooled fluid is mixed with an equal part, by weight, of glycerine and in this is dissolved the same quantity, by weight, of gum Arabic. In this fluid the most delicate plant organisms are preserved admirably and in addition it is not liable to evaporation, which, in hot countries, is of great value.

ENGINEERING NOTES.

Dredging companies in the Klondike are reaping golden rewards for their enterprise from ground worked over during the Klondike excitement, and also from ground which never before paid. On one concession a dredge working where the pay was never supposed to exist, has been turning over 4,800 cubic yards of dirt a day. The pay has been good, and the company has enjoyed a prosperous season. On another property a company has been sluicing on an average 2,800 cubic yards a day.

Asbestos wood is a new material consisting of fireproof asbestos cement slate lined on one or both sides with wooden veneers according to a special method. This material is extremely compact, and resembles natural wood in aspect and properties. It can be sawn, drilled, milled, slotted, and planed. It is entirely fireproof, the coating of veneer charring very slowly under the action of intense heat. Asbestos wood is a substitute both for natural wood and metal. It is a non-conductor of heat and sound, and affords a most efficient protection against heat and cold. The material is used to advantage as wainscoting for walls and ceilings, as well as for the manufacture of fireproof furniture.

In planning for enterprises involving the use of water in streams, the engineer has to base his estimates of the quantity and distribution of the flow that may be expected in the future on records for past years. The flow of a stream is a constantly changing quantity and neither the total quantity nor its distribution for any year will probably ever be the same in any other year. By the study of long series records of flow of the Ohio River at Wheeling, W. Va. (drainage area 23,000 square miles), the Tennessee River near Chattanooga, Tenn. (drainage area 21,400 square miles), and the Sudbury River at Framingham, Mass. (drainage area 75.2 square miles), it has been found that there occurs in practically each period of 10 years investigated a year of average low water and also of average high water. While this low and high may not be the extreme, it gives nevertheless the mean condition which may be expected with the exception of the abnormal year, which as a rule only occurs once in many years. It is believed, therefore, that a 10-year period will give a fair idea of the flow that may be expected on any eastern stream.—John C. Hoyt, in Engineering News.

Everybody admits that it would be a mistake to go back to the old cable cars, or to steam-driven cars. Similarly, nobody would advise having the auxiliaries of rolling mills driven by steam. But the driving of large mills is another matter. It appears to have a striking resemblance to the installation of large electric hoists for deep mines. A couple of years ago engineers in Germany were extremely enthusiastic on the subject of large electrically-driven hoists. But in the last two years they have gone back to steam. Why? The first report of the superiority of the electric hoist surprised everybody. In some cases half of the original battery of boilers could be shut down. But the reason for this was that these electric hoists replaced steam engines of the most inefficient description. An advance in one line stirs up the competitor; the engine builders re-designed their machines to effect a saving in steam. They built hoists driven by twin tandem compound condensing engines, with governors and suitable regulating devices to prevent the operating engineer from wasting steam. The result is that the new steam hoists show even better economy than the electric, and save a great deal in first cost. It must be understood, however, that these hoists are large units, probably 4,000 horse-power.

According to the Engineering Record, the Poetsch freezing process has been employed in sinking two shafts for the de Wendel Colliery at Klein Rosseln, near Forbach in Lorraine. Previous difficulties at this place with the Kind-Chaudron trepan system and with the ordinary method, in which reliance is placed on pumps for removing water, led to the adoption of the process before the work was begun. An advance pit 33 feet in diameter and secured by a temporary iron lining was sunk by hand to a depth of about 80 feet. Twenty-seven holes were then started at that depth, equally spaced on the circumference of a 24-foot circle. Two of them were bored with a diamond drill, so as to show the character of the materials penetrated, and the others were sunk by churn drills. The holes were carried down mainly through sandstones and conglomerates to a depth of 613½ feet below ground, and in them were placed the pipes for the freezing fluid, a 10 per cent solution of chloride of calcium. The pipes had a total length of 2.6 miles and a cooling surface of 16,300 square feet. The shaft was sunk at the rate of 21 feet per month, inclusive of the time spent in boring and freezing. The shaft was lined with tubbing up to the ground water level and with concrete above that point. The second shaft was sunk in the same manner, but the boring of the freezing holes was started considerably lower.

TRADE NOTES AND FORMULÆ.

Explosion Preventive Powder (for kerosene lamps). —I. 16 parts of common salt, 0.4 part of carbonate of soda colored blue with ultramarine. II. 74.88 parts of carbonate of soda, 21.34 parts of mannite, 1.31 parts of sand, 2.47 parts of water. III. 75 per cent of soda, 25 per cent of sugar of milk.

Fellner's glaze for stove tiles consists of 141.48 per cent of silicic acid, 23.84 per cent of oxide of tin, 23.73 per cent of oxide of lead, 37 per cent of alumina, 0.29 per cent of oxide of iron, 0.66 per cent of lime, 1.94 per cent of potash, 3.93 per cent of soda. To obtain this combination, melt together 36 parts of quartz sand, 23 parts of oxide of tin, 24 parts of red lead, 12 parts of kaolin, 1 part of chalk, and 9 parts of calcined soda.

Waterproofing of Felt.—To each 1,000 parts of good, pure linseed oil (not varnish) and petroleum, 500 parts of turpentine, 125 parts of yellow wax, the latter in small fragments, are dissolved in a vessel, if possible a copper vessel, over a bright coal fire. Boiling of the mass, as there is risk of fire, must be avoided. In the hot solution, removed of course as far as possible from the fire, the felt material is steeped, then it is hung up or spread out in a warm, dry place, so that the surfaces can be acted upon by the uniform temperature.

Phosphorescent Colors.—In their preparation, Mourelo mixes 285 parts of carbonate of strontium (crude), 68 parts flowers of sulphur, 4 parts crystallized sodium carbonate, 2.5 parts sodium chloride, and 0.4 part hyposulphate of bismuth, in thoroughly pulverized condition, placing the mixture in an earthen crucible and covering with a layer of pulverized starch. The crucible is kept heated by coke fire, in a furnace, for five hours, to a red heat, and then allowed to cool for ten to twelve hours. We obtain from the crucible an almost white, granulous, brittle substance, possessing a marked phosphorescent capacity that is excited by the least possible light.

Imitation Ivory.—An inventor has discovered a new method of imitating ivory, which, owing to the rapid extinction of the elephant, has become very costly. The imitation is deceptively similar to and is said to possess the same hardness as the genuine article. He uses in its production the substances of which the genuine ivory consists, i. e., tribasic phosphate of lime, carbonate of lime, magnesia, alum, gelatine, and albumen. In his process caustic lime is treated with a sufficiency of water to transform it into a hydrate; but before it is completely converted into a hydrate an aqueous solution of phosphoric acid is poured on to it, and during the mixture the caustic lime, the magnesia, and the alum are gradually added in small quantities and finally the gelatine and albumen, both dissolved in water, are added. Care must be taken to produce a plastic and as far as possible well mixed mass. It is then left to stand for a day, to afford the phosphoric acid an opportunity to work on the chalk. Thereupon the mass is transferred to the desired molds, for instance, billiard balls, knife and other handles, etc., and dried for a short time in a current of air at a temperature of 312 deg. F. (150 deg. C.). After four weeks, the objects are perfectly dry and are said to resemble the genuine ivory more closely than any other substitute mass as yet discovered. The proportions of the above specified ingredients used are as follows: Caustic lime 100 parts, water 300 parts, solution of phosphoric acid (of 1.05 specific gravity) 75 parts, carbonate of calcium 16 parts, magnesia 1 to 2 parts, alum—precipitate—5 parts, gelatine 15 parts. It is of course understood that the various objects, after they are made, can be given any desired color.

TABLE OF CONTENTS. PAGE

ULÆ.
e lamps).
bonate of
.88 parts
1.31 parts
t of soda,

41.48 per
tin, 23.73
mina, 0.29
ime, 1.94
o obtain
f quartz
lead, 12
calcined

of good,
eum, 500
he latter
l, if pos-
Boiling
avoided.
as pos-
ed, then
place, so
uniform

on, Mou-
trontium
crystal-
chloride,
oroughly
earthen
starch.
furnace.
to cool
crucible
ce, pos-
t is ex-

a new
he rapid
costly.
said to
cle. He
ich the
of lime,
d albu-
with a
ate; but
rate an
on to it,
agnesia,
antities
olved in
oduce a
. It is
osphoric
ereupon
for in-
es, etc.,
ir at a
er four
said to
y other
tions of
ollows:
tion of
rts, car-
parts,
It is of
er they